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ABSTRACT

The United States is facing a great crisis: skills gaps in the work force imperil the nation's future. The crisis is elementary: the United States is not educating and training its citizens to be productive and competent members of the work force. Consequently, its people are not qualified enough to meet the demands of the high-technology economy of today and tomorrow. Unless reform is undertaken, the outcome is obvious. Faced with hiring from an uneducated and illiterate pool and saddled with the extra cost of training poorly educated workers, U.S. industry will lose the global economic race. Given the failure of the U.S. system of education, training and retraining in industry have assumed great importance. But industry's expenditures are constrained by the need to remain profitable. Although actions are underway at all levels, these initiatives do not go far enough. The U.S. education system needs to be overhauled, not just remodeled or restructured. A cultural revolution is needed. Educators at all levels, including administrators, as well as unions need to start acting as if they, too, have a part to play in producing a technically competent work force. Their futures depend upon it as much as the nation's does. Concerned, cooperative leadership in the Federal Government is needed, along with leadership from business and industry, unions, local and state governments, and associations. Such action is imperative for the future of the country. Chapters deal with the technical labor force, the global marketplace, U.S. education, the workplace of tomorrow, and current programs. Chapters include graphs and a list of citations. The document includes a 233-item bibliography. (KC)

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AMERICA's NEXT CRISIS

The Shortfall in Technical Manpower

An Aerospace Education Foundation Study,
Prepared in cooperation with FCB Associates
September 1989

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
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EXECUTIVE SUMMARY

The nation is menaced by a quiet crisis as damaging as drugs or terrorism. The crisis: skills gaps in the American workforce imperil the nation's future. They endanger domestic prosperity and the U.S. position of world leadership. The United States faces a crisis situation as hazardous to its future as if several enemies attacked simultaneously.

This crisis is home-grown, not a foreign threat. It is a self-inflicted wound that threatens to destroy the U.S. competitive edge unless healed by prompt and drastic actions.

An abundance of reports and studies describe and lament the multiple facets of the deficiencies in technical manpower. Skilled workers of all types are in short supply, from technicians to engineers and scientists. Even worse, persons emerging from the education pipeline are unqualified for the most basic entry-level jobs. The problem extends from dishwashers to Ph.D.s. Moreover, all of the studies agree that not only are the shortages serious, the trends are worsening.

Many of these reports have even generated national media attention. Since "A Nation at Risk: The Imperative for Educational Reform" was produced by the National Commission on Excellence in Education in 1983, dozens and dozens of related reports and studies have followed.

But after the initial shock of the various findings subsides -- and the sensational headlines fade from memory -- nothing happens. Our national leaders know what the problem is. Our top educators also know what the problem is. U.S. industry continues to suffer because of the problem. And ultimately, America suffers.

For example, between 1989 and 2010, the National Science Foundation estimates that the nation will be short more than 700,000 scientists and engineers. But what is being done to fill the need? Very little, if anything.

The crisis is elementary: the United States is not educating and training its citizens to be productive and competent members of the workforce. Consequently, its people are not qualified enough to meet the demands of the high-tech workplace of today and tomorrow. The lack of technologically skilled workers then cripples U.S. industry, which essentially knocks the nation out of the global competition before it even gets into the game.

For decades, from the immediate postwar years to the late 1960s, the United States was preeminent. Its products dominated world markets. Now it faces a truly global marketplace, and is no longer dominant in many segments of that global village. It still leads in innovation, and its economy is still the largest, but others have taken the lead in applying innovations to products that command market share.

In the future, moreover, the United States will probably lose even more ground unless the declining trends are reversed. According to the U.S. Census Bureau, by the year 2000, if current trends continue, 70 percent of the U.S. population will be functionally illiterate -- and, consequently, unemployable.

If American industry already must put up around $30 billion a year for the remedial

education needed to train its workers, how well can U.S. firms expect to do at the turn of the century against foreign companies who can direct all their resources into doing business? No matter how extensive "in-house" corporate training and education programs may be, industry must rely on the public schools to graduate a sufficient number of educated workers.

Unless reform is undertaken, the outcome is obvious. Faced with hiring from an uneducated and illiterate pool and saddled with the extra cost of training poorly educated workers, U.S. industry will be trampled upon globally, left in the dust.

In fact, other countries are already edging ahead of the United States in many areas: and education is one of them. Education is critical to all other national endeavors.

But the American education system has failed the nation. In education, from the earliest grades to high school, U.S. students lag far behind their counterparts in other countries. U.S. 9th grade students placed next to last among 15 countries in science tests. At college and graduate level foreigners take increasingly higher percentages of the advanced degrees in science and engineering.

According to The Task Force on Women, Minorities, and the Handicapped in Science and Technology, "Today, 75 percent of the graduate students receiving financial support from university engineering departments are foreign nationals."

Industry has had to work with, and more often work around, the deficiencies of the current education system. Given the undeniable failure of the American system of education, training and retraining in industry have assumed great importance. But industry's expenditures are constrained by the need to remain profitable. Moreover, basic education is not normally the job of the business community. The graduates of the education system at all levels, however, are supposed to be productive members of society. So education for life is everyone's business.

In recent years, the United States has neglected its most precious resource -- its human capital. In the past, the nation capitalized upon its human and natural resources to advance and prosper. Examples include the Homestead Act and the Morrill Act (endowing land-grant colleges) and the G.I. Bill of the post-World War II era. But now its human capital has been allowed to wither through neglect.

In preparing this study, we have found abundant evidence that actions are under way at all levels -- local, state, national -- to create remedies for the educational and training ills that imperil the nation. Their common characteristic is best expressed in a single word: partnership.

At the national level, numerous acts and initiatives provide seed funds and set standards for local and state programs. Several states, with their constitutional franchise for education, have enacted legislation and provided funds aimed at state solutions for state problems. At regional and local levels, hundreds and perhaps thousands of partnerships are flourishing. They involve local governments, schools and industries working together.

But these initiatives do not go far enough. They treat the symptoms, not the problem. Most of the partnerships working to overcome educational deficiencies are successful for a simple reason: they bypass "the system," because it does not deliver.

And based on the abundance of evidence generated by myriad commissions and study groups over the past decade, the solution to the technical manpower crisis is clear enough, but it is also politically explosive. The U.S. education system needs to be overhauled, not just remodeled or restructured. Indeed, *perestroika* would not go far enough; the U.S. education system needs a cultural revolution.

Examples of basic structural deficiencies abound. There is a teacher shortage, for

instance. But the shortage is not so much a problem of numbers of teachers; it is a problem of the quality of teachers entering the technical fields such as mathematics, science and engineering. The best and brightest are not becoming teachers; the cheapest are. Yet, instead of welcoming into the fold scientists and engineers who want to teach, the system turns them away.

Why? Because teachers' unions feel threatened and administrators do not want to face the task of restructuring the certification system. Unions and administrators have also openly opposed initiatives like magnet schools, which are designed to improve education by offering choices at quality schools.

The teachers' unions also were conspicuously absent from the innovative partnerships and alliances being formed at local, state and regional levels to redress failures of the system. If union leaders do not believe they have a stake in reforming the educational system to achieve quality education, just what is their role? It is time for unions either to become part of the solution or to step aside. Up to the present, unions have attempted to block reform initiatives without offering any alternatives. But their adherence to the status quo can be tolerated no longer.

Educators at all levels, including administrators, and unions need to start acting as if they, too, have a part to play in producing a technically competent workforce. Their futures depend upon it as much as every other American's does.

While the federal government can act as a catalyst, true change can only come about through dynamic interaction among individuals, the business community, the education establishment, labor and local and state governments. At the federal level, alongside the interagency approach taken to fight the war on drugs, a similar war on technical incompetence ought to be waged by an "education czar," namely, the Secretary of Education, backed by the President, who would coordinate all the federal actions required to arrest the decline.

The state of the nation's human capital ought to be a national priority and national concern. But this is not the time to rely on Washington for solutions. The impetus, the force, must come from the local and state levels, with individuals and groups demanding action and creating reform.

Another key ingredient is required: communication, a sharing of information nationwide. With communication and leadership, a new course can be charted and local actions multiplied to create national change. But to chart the course to reform does not require more studies and commissions. The staff work has already been done. Now it is time for action.

Our recommendations are simple rather than sweeping, pragmatic rather than visionary. The national leadership, both tangible and symbolic, is already in place and committed. President George Bush has already taken the lead with his education proposals, and Mrs. Barbara Bush has long been dedicated to curbing illiteracy.

• Now we recommend the president expand coordination among departments of the Executive Branch to address the many challenges of the technical manpower shortages. In addition, we urge that he direct an information collection and dissemination effort government-wide, and designate a single Cabinet officer -- the Secretary of Education -- as the focal point for compiling the information into useful and distributable form. In the process, the federal government should develop education and training standards and criteria that reflect the reality of the situation.

• Other actions that should be taken by the executive branch are procedural. They include allowing government contractors to consider funds spent on training and education as allowable expenses, including funds spent on business-labor-school partnerships.

• Congress should devise tax incentives to encourage corporations to commit funds to qualifying the workforce at all levels. That

could include creating depreciation allowances for such expenditures because they increase the value of an asset, the workforce. Congress should also support and validate actions by the executive branch to qualify the workforce.

• Recommendations for the private sector are aimed at creating leverage and impact for programs already under way and to create new programs. A major thrust for the private sector is to stimulate appropriate government actions at all levels.

• Industry should invest in human capital, directing its investments toward qualifying the present and future workforce. Industry should seek opportunities to invest in education and training partnerships at all levels.

• Organized labor should seek opportunities for partnerships with industry and the education sector.

• Associations can play a strong role in this effort. They extend from the grass roots to the state legislatures to the corridors of power in Washington. Associations should foster nationwide information exchange among their members, with other associations and with other sectors of society. In that regard, associations can act as clearinghouses and resource centers. They can and should augment and stimulate the information collection and compilations of government, but not wait for government to act.

• Local and state governments, representing the American public at the grass roots level, ought to demand change in their school systems. That could mean getting rid of the culprits on school committees, lobbying for changes in state laws designed to permit more innovation, and taking on labor unions. In fact, it may be time to create new school systems based on a more cooperative model of teacher-administrator interaction that includes better pay and benefits for teachers, as well as alternate incentives to attract talented people into teaching.

When Nissan Motor Co. created a cooperative environment between management and labor at its plant in Smyrna, Tenn., employees found there was no need for the union. In fact, they handed the union a humiliating defeat when asked if the union should represent them. School systems might find that they are better off without unions, too.

An unparalleled opportunity exists for the government and private sector to work together to cope with this national crisis. Every action taken to qualify the workforce, whether in education or training, increases the national assets the United States will need to win in the future.

Under the present circumstances, there is one sure way to lose: that is to continue to treat short-term symptoms while putting off politically difficult cures until tomorrow. Tomorrow is already here.

TECHNICAL MANPOWER

A Paradox of Weakness and Strength

Technology: The Prospect of an Empty Harness

One of the best descriptions of technology appeared in the "Report of the Project 2061 Phase I Technology Panel." Its author, James R. Johnson, defined technology as "the application of knowledge, tools, and the skills to solve practical problems and extend human capabilities." "Technology is best described as process," he continued, "but it is more commonly known by its products and their effects on society. It is enhanced by the discoveries of science and shaped by the designs of engineering. It is conceived by inventors and planners, raised to fruition by the work of entrepreneurs, and implemented and used by society. Sometimes, though, it enters the social system imperceptibly and brings about many changes, often in unforeseen ways."[1]

Technology is indeed the vital link between man and society. It has historically, and in the very recent past, been responsible for mankind's progress -- and it will continue to be. But ultimately, progress depends upon mankind's ability to harness technology, to control it, and to make use of it for the benefit of all.

As the United States faces a growing shortage of technical manpower across the board, an obvious question follows: Who will hold technology's reins tomorrow? Will anyone be pulling in the harness? What kind of people are needed?

Johnson says what kinds of technical manpower the nation needs: "Therefore, young adults (and others, we might add) should know some of the underlying basic science, mathematics, and engineering concepts and their relationship to technology. They should be familiar with the use of the basic tools involved, from applied mathematics to design, to computers, to hardware. They should understand that technology does not stand apart from the society it serves."

The crux of the technical manpower problem is that too few people in the workforce today have the skills required to function in a technologically advanced society or are trained to understand these fundamental relationships. In the end, this gap, or "deficit," dulls the nation's competitive edge. In the long run, if the technical manpower gap widens and the adverse trends persist, our very economic survival is in jeopardy.

US Trade Deficit: Losing the Competitive Edge

Figure 1.

Source: International Trade Administration

A New Kind of Deficit

Throughout its history, the United States has made use of its assets to grow and prosper. For two centuries this nation capitalized on its God-given natural resources, on its people and on its guarantees of freedom. From the nation's earliest days, the beacon of freedom shining from the United States attracted millions of people willing to suffer in order to create a new life as free men and women. Successive waves of immigrants arriving on its shores enriched the United States and provided the brains and brawn to fuel the nation's growth.

U.S. growth to world leadership was fostered by the free use of capital applied to untapped resources to create new products, processes and markets. The term "capital" varied in meaning depending on the situation. In some cases, it meant money committed to a venture, such as the fur trade or transcontinental railroads or steel mills. In other instances, "capital" was synonymous with the brainpower that invented devices to expand production, such as Whitney's cotton gin, Deere's plow and McCormick's reaper. In each instance, the result of applying the capital of American brainpower was an invention that attracted financial capital which, in turn, was used to exploit the capital of natural resources. Natural resources and human resources abounded -- unlimited fertile land and growing numbers of people to work it as the nation expanded.

Two enduring examples of the nation's use of one form of capital to invest in another form are the Morrill Act of 1862 and the World War II G.I. Bill of 1944. Both acts served as catalysts and had a positive and profound effect on national development. President Lincoln signed the Morrill Act on July 2, 1862. It converted the idle capital of public lands into a means of realizing the potential in the human capital of several states. Income from the public lands was granted to the states to endow land-grant colleges. The land-grant colleges were managed by each state, but conformed to the broad policy stipulations of federal law.[2]

The basic intent of the act was to have at least one college in every state to "teach such branches of learning as are related to agriculture and the mechanic arts . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life."[3]

Until the Morrill Act, university education in the United States existed almost exclusively for the leisure class, government leaders and members of the professions. The Act made higher education available to millions, and contributed mightily to national development. Reflecting on the Act 25 years later, Justin Morrill summarized his intent this way: "The fundamental idea was to offer an opportunity in every State for a liberal and larger education to larger numbers, not merely to those destined to sedentary professions, but to those much needing higher instruction for the world's business, for the industrial pursuits and professions of life."[4]

Among its other provisions, the Morrill Act stipulated that military tactics should be part of the curriculum of the land grant colleges. That was the beginning of military instruction in civilian colleges, and the origin of the eventual Reserve Officers Training Corps (ROTC), a fruitful source of trained officers from World War I to the present time, especially during World War II, when nearly 10 percent of the population was called to arms.[5]

More than a year before victory in World War II, President Franklin D. Roosevelt signed the "G.I. Bill of Rights" on June 22, 1944. The G.I. Bill created a comprehensive range of benefits for returning veterans. In contrast to the aftermath of earlier wars, leading provisions in the bill provided servicemen and women with educational opportunities, plus vocational or on-the-job training. Other sections guaranteed farm and home loans. Its provisions reflected well the congressional execution of President Roosevelt's stated goal concerning returning servicemen and women, enunciated in his message to Congress on November 23, 1943: "The goal after the war should be the maximum utilization of our human and material resources."[6]

More than 7,800,000 veterans of World War II participated in G.I. Bill education and train-

ing programs. Of that number, more than 2,230,000 studied at college level, 3,480,000 below college level; 1,400,000 took on-the-job training; and 690,000 participated in on-farm training. At the peak enrollment month (November 1947) more than 2,546,000 World War II veterans were enrolled in education and training programs.[7]

Besides providing the benefits cited above, the G.I. Bill prevented the complete disruption of American economic life. By attracting returning veterans to pursue education and training, the bill helped smooth the transition from war to peace.

But not all the early reactions from educators were positive, as they faced the prospect of welcoming hordes of returning veterans. Robert Maynard Hutchins of the University of Chicago said in 1944 that "colleges and universities will find themselves converted into educational hobo jungles." From Harvard in 1945, James B. Conant said the bill was "distressing," because it did not "distinguish between those who can profit most by advanced education and those who cannot."[8]

Fortunately, they were in the minority. A few years later, Conant's successor as president of Harvard, Nathan M. Pusey, called the veteran students ". . . an able, mature, energetic, determined student body."

Dr. Edward B. Bunn, S.J., president of Georgetown University, said, "I know of no direction in which Government money has been spent more fruitfully for the training of future American citizens." On the 25th anniversary of the World War II G.I. Bill, the Veterans Administration called it an unexpected bargain, saying, "The better-educated, higher earning veterans are returning taxes to U.S. coffers at a rate expected to repay the entire government funds expended as much as thrice over in the course of their lifetime."[9]

Clearly the Morrill Act of 1862 and the G.I. Bill of 1944 were examples of how to make sound use of the nation's human resources. But, in the 1980s, the failure to take advantage of the untapped human resources drains the nation -- it doesn't replenish or advance it.

Consider the current costs that educational deficits impose on society. Commerce Secretary Mosbacher put it this way: "Illiteracy, dropout rates, underachievement; all these cost business and society dearly. Dropouts alone cost our society in wasted human potential, lost taxes and wages and public assistance, over $240 billion annually. And business must spend over $30 billion every year to train and retrain employees. One in three companies must provide basic or remedial instruction to newly hired workers."[10]

If Secretary Mosbacher's estimates are near the mark, then dropouts alone cost the United States more than twice the annual budget deficit.

Shortfalls in the American Workplace: Is there a Problem?

The basic problem is indeed a "skills gap." Unlike the elusive missile gap of the 1960s, this gap is real and hazardous. Schools in the United States are still not producing graduates with the technical skills required for entry-level jobs in industry or even the basic survival skills for everyday life. At the same time, the demand for workers continues to be strong and is forecast to remain so.

Six full years of economic recovery have produced the tightest labor market in decades, says Audrey Freedman, management counsellor at The Conference Board, and chair of the Board's 1989 Human Resources Outlook panel. "Business seems to have reached the edge of the population's capacity to produce additional trained workers. In some localities, especially around Boston, there are no workers available 'at any price.' Employers are staffing their operations with greater difficulty and at rising cost."[11]

The *New York Times* reports that the U.S. Senate has responded to the emergency by "approving changes in the immigration laws that for the first time would establish a system of ranking some visa applicants by their work credentials. Although only 54,000 people a year will be granted permanent entry solely on the basis of their skills, a precedent was set and sides were taken in what will be a long debate over how much the United States will meet its labor needs with foreigners."[12]

Acute shortages also affect the more skilled technical and scientific segments of the workforce. The Task Force on Women, Minorities, and the Handicapped in Science and Technology noted in its report on changes in science and engineering that ". . . one of our most urgent tasks is to strengthen our science and engineering workforce. The education pipeline -- from prekindergarten through the Ph.D. -- is failing to produce the workers needed to meet future demand. Indeed, unless parents, schools, colleges, professional societies, industry, State legislatures, Federal agencies, the President, and Congress act in concert, our national science and engineering workforce will continue to erode and the prospects for maintaining an advanced industrial society will diminish."[13]

The problem is not static; in fact, it is worsening. While the number of new jobs in U.S. industry is growing, the number of new entrants is shrinking. The same task force forecast the probable shortage ahead. It said, " . . . by the year 2010, we could suffer a shortfall of as many as 560,000 science and engineering professionals. As a result, America's economic strength, security, and quality of life are threatened."[14]

It also highlighted the heavy foreign composition of the persons studying engineering: "Today, 75 percent of the graduate students receiving financial support from university engineering departments are foreign nationals."[15]

A study conducted jointly by the Departments of Education, Labor and Commerce in 1988 concluded: "The basic skills gap between what business needs, and the qualifications of the entry level workers available to business, is widening."[16]

This problem affects the military as well, since it must compete with industry and universities for this small pool of new and often unskilled labor. Former Air Force Secretary Verne Orr noted that the Air Force requires a technical background in 72 percent of its enlisted specialties. Yet, he forecast in 1983 that by 1993, 20 percent fewer young people will enter the workforce and the military. Furthermore, those young people will have less scientific and technical ability, despite the requirements of industry and the military.[17]

Nine years ago, Gen. Alton D. Slay, then commander of Air Force Systems Command, cited severe shortages in qualified engineers in his command, which is responsible for Air Force research and development. He also pointed to the shortages of skilled production workers in industry. General Slay singled out the tooling and precision machining industry as especially vital to the national security, because "it is the keystone of our mass production economy." The National Tooling and Machining Association (NTMA) verified General Slay's forecast, projecting a very large deficit in skilled journeymen in that essential field.[18]

The other armed services face problems similar to the Air Force. Throughout the Army, for instance, the average math literacy is still around 9th- or 10th-grade level. On the other hand, new technologies are doubled-edged. They provide part of the answer to the skills gap -- just push a button and a missile guides itself to a target. But they compound it further, because to effect a complex repair, mechanics today simply pull out one "black box" and replace it with another.[19] The mechanic need not understand what the box does. For this reason, some contend that technology allows the military to go soft on math. It might be compared to what the calculator did to basic arithmetic skills throughout the country over a decade ago.

According to Raymond Reed of Rockwell International, "Technicians must be able to read at the 12th grade level or above since technical, safety, and quality control manuals are written at this level."[20] But persons emerging from the education pipeline are deficient in those essential skills.

Learning from the Competition: "Disorder" Isn't So Bad

Nothing illustrates better the challenges, potential pitfalls and opportunities facing the United States in the 21st century than the present U.S.-Japanese economic competition. According to the conventional wisdom, Japan is poised to overtake the United States as a

world economic power -- and many believe there is little that Americans can do to prevent the Japanese from running away with the ball.

During the seventies and early eighties, American businesses were captivated by the idea of borrowing Japanese management philosophy and techniques. As U.S.-Japanese joint ventures were established, the American public was treated to the spectacle of American auto workers doing calisthenics in the morning at Japanese-owned companies. This, according to Japanese industrial philosophy, would build a team spirit. American workers, however, seemed more content to grab a cup of coffee at first light than a pair of gym shorts.

In fact, when Japan tried to export its best-known management training program, its reception was even less than unenthusiastic. According to a 1987 article in *Fortune* magazine, the Kanrisha Yosei management school's "hell camp" for upwardly mobile Japanese managers, consisting of 13 days of hazing, calisthenics, night hikes and action debates, got very few takers when offered to U.S. executives.

Richard Phalon of *Forbes* wrote: "In Japan, Kanrisha is known as the management training equivalent of the Parris Island or Fort Benning boot camps. Leather-lunged instructors chivy their charges through 16-hour days and endless repetitions of the proper way to write reports, deliver speeches, talk on the telephone, look after the health of subordinates, hammer out quick decisions. Only after passing tests can a trainee have removed the 'ribbons of shame' pinned to his Imperial Navy-type jumper. These ribbons are designed to remind trainees that the individual is nothing, the group everything -- a very Japanese and equally un-American way of looking at the world."[21]

This does not mean, however, that borrowing techniques from the Japanese is a bad thing to do. In fact, America has been hurt more often than not by an unwillingness to adapt tried and true methods from the competition. The not-invented-here syndrome is commonplace in the self-assured individualism at the root of America's past success.

Yet, without necessarily mimicking wholesale the Japanese -- or others, for that matter -- Americans ought to be able to draw strength from their individualism, all the while selectively adopting education, management and production techniques that are particularly well-suited to the American character. For example, just-in-time inventory control methods and better procedures for quality control might prove valuable to U.S. businesses while the artificial imposition of team-building techniques related to a collective, consensus-oriented culture may not.

Where managers of Japanese-owned American firms have selectively adopted some Japanese management techniques, the result has been rather impressive. The two-to-one rejection of the United Auto Workers by Nissan Motor Corp. employees in Smyrna, Tenn., suggests that some U.S. workers not only have accepted many aspects of the Japanese management approach, but also seem to prefer it to the tired ideas and outdated approaches advocated by American labor unions.

The real answer not only to remaining competitive, but also to winning in the global marketplace, is to preserve that spirit of individual initiative and ingenuity that made America great in the first place while adapting to new realities. While that doesn't mean aping the West Germans or Japanese, it also doesn't mean shortsighted arrogance or the not-invented-here syndrome.

When applied to the workforce, it means educating workers to meet the challenges brought about by new technologies and an interdependent world economy while also encouraging them to be "true to themselves."

James Fallows came to this conclusion after spending several years in Japan and Malaysia. In his recent book, *More Like Us*, Fallows makes a valid point. "If we have to out-cooperate and out-sacrifice the Japanese," he says, "we may as well quit. We need, instead, to find our own tools."[22]

As opposed to the highly ordered approach of the Japanese, Fallows notes that Americans possess a high tolerance for "disorder." We even thrive on it. He asserts that

"America has developed much more rapidly than other societies because it has been willing to endure extreme disruption. It has endured disruption, in turn, because individual Americans have been so quick to adjust." American culture, according to Fallows, has a self-made quality about it -- and that is an inherent strength.

Tom Peters applies this American proclivity to the business world. In his book, *Thriving on Chaos*, he argues that the perceived lack of direction in U.S. industry may not be all bad. In fact, when the innovators and leaders have a clear sense of order and vision, the "chaos" below them is often healthy and productive – despite appearances to the contrary.[23]

Unfortunately, in the areas of education and training, no national goal and vision has been imposed on the chaos below. President George Bush aspires to be the "Education President," yet little action has been taken to really tackle the problem.

To become the Education President, George Bush will have to finish what former Education Secretary William Bennett began: he will have to take on the education establishment and prod it into changing.

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THE BIG PICTURE

A Global Marketpalce

The Global Village: Americans Take Note

Technology and events have shrunk the globe in the postwar years. Thanks to satellites, telecommunications and computers, the financial markets operate globally around the clock. Air transport moves people and things in numbers that exceed the most optimistic projections of the past. In the present day, no nation, least of all the United States, can be isolated. The "global village" is too pervasive and interdependent.

The 50 state governors recognize this situation every bit as well as the internationalists of government and industry. Gov. Gerald L. Baliles of Virginia, said, "Billions of dollars move in seconds from Milan to Tokyo to New York. Goods move across continents in a single day. An individual product may contain parts manufactured in five different countries and be assembled in a sixth."

In 1989, as chairman of the National Governors' Association, Governor Baliles created six NGA task forces to examine the issues that form the foundation for the nation's future. The NGA Task Force on Research and Technology examined the situation and prescribed courses for the future. The first step in the process, the task force noted, was to acknowledge that "the economic sovereignty once enjoyed by the U.S. has been reduced." States, once bystanders to international events, are now players in the global marketplace.

When introducing the report, Gov. Baliles added, "New markets and opportunities emerge almost overnight. In this competitive and rapidly changing environment, success belongs to those who can anticipate, adapt and respond quickly."[1]

The global marketplace has been recognized at the federal level, too. Commerce Secretary Robert Mosbacher told a Senate committee, "The struggle we're in is that it is a global marketplace today. We still operate as if we were in the 1940s and we can distinguish (between markets)."[2]

The global marketplace and the diffusion of information create opportunities as well as challenges for U.S. corporations. Given the international dimension of today's marketplace, it is not necessary to invent everything here. As the President's Council on Competitiveness suggested, with globalization of all aspects of the commercial process, U.S. companies "must become as much hunters and gatherers of technology as they are generators . . . "[3]

Businessmen and educators concur and also point to the need for a skilled workforce as an essential ingredient for successful competition. According to one report, " . . . the competitive global marketplace, increased domestic competition due to deregulation, the pace of technology development, shorter product life cycles, and new flexible production processes all require more adaptable, more highly educated entry workers in order for our country to remain competitive."[4]

U.S. citizens, too, recognize the global challenge and perceive the required remedies. In a Louis Harris poll, 81 percent of Americans agreed that how well the United States educates its labor force to new skill levels will

make a major difference in whether this country maintains a leading economic position in the world.[5]

The situation, along with its inherent challenges, has been acknowledged in various ways by government (at Federal and State levels), by the business and education communities and by a representative sample of the population.

Human Capital: America's Ace in the Hole

According to *Made in America: Regaining the Competitive Edge*, a two-year study by the M.I.T. Commission on Industrial Productivity, future American competitiveness will depend on how well the United States blends technology and human resources in order to create better forms of production. The study concludes that it is necessary to treat the workforce as an asset rather than a cost.

According to the Business-Higher Education Forum, that means investing in our human capital. "Too much of our human talent is being wasted," its report states, "and a growing proportion of the next generation is slipping beyond the reach of the institutions and values of our society."[6]

According to that report and a number of others, the greatest waste of human capital occurs among women and the nation's minorities. Women, for instance, make up 50 percent of all professional workers, but only 24 percent of scientists and 4 percent of engineers are women. Additionally, the Business-Higher Education Forum points out that although Blacks, Hispanics and American Indians represent about one-fifth of the U.S. population today -- and will make up about one-third of it within 20 years -- they account for less than 2 percent of the doctoral degrees in the physical sciences and engineering.[7]

A major challenge, then, is to find a way to tap into the pool of undeveloped talent. However, the problem is more complex. Some analysts have blamed America's relative decline in its competitive position on the loss of the work ethic. The MIT researchers did not. They said instead, "Our research on productivity and the quality of the work force suggests a very different explanation. We think the origins of the problem lie not in the disappearance or weakening of basic American values and capabilities but in the institutions that educate Americans for work."[8]

They are right. Innate American values and capabilities are indeed present. A large part of the blame for not realizing their potential should be placed on the doorsteps of America's educational institutions. But there are many aspects of the technical manpower problem -- and enough blame to go around. Government and American industry have also been shortsighted.

Even though America's wealth of raw human "materials" represents this country's ace in the hole, U.S. educational and training institutions are ill-equipped to capitalize on and exploit these resources.

Charles Ferguson, a research associate at the Center for Technology, Policy and Industrial Development at MIT, blamed America's high-technology decline not just on one area or policy, but on a number of domestic problems that were accentuated by increasing external competitive pressure.[9]

Ferguson cites the "shortsightedness and rigidity in U.S. government policies, industrial structure, and corporate strategy. These institutional rigidities," he continues, "includ-

Minorities: A Wasted Resource

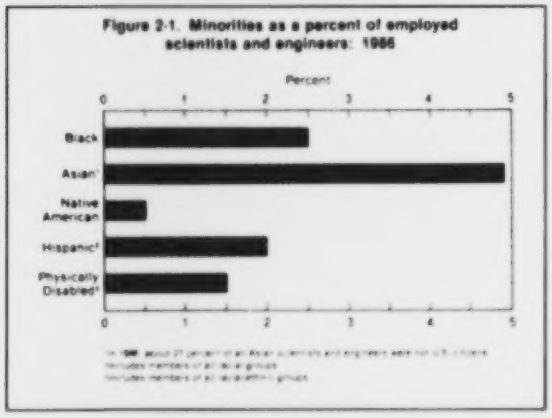

Figure 2

Source: National Science Foundation

ed continued reliance upon tax and economic policies biased toward consumption; a fragmented political and economic structure that impeded long-term technological and strategic coordination; policies for basic research, higher education, trade, and military systems that allowed other countries to enjoy asymmetric access to U.S. technological resources . . ."

According to Ferguson, these problems remained unnoticed because they coincided with a period, roughly from 1945-1975, when America dominated global high technology. During that period, Japan pursued an integrated strategy designed to restrict American imports, while at the same time massively importing U.S. technology and capitalizing on American basic research.

As Japan developed and implemented its own strategy, its success took many Americans by surprise. Naturally, success prompts others to imitate: and this is exactly what many American businesses tried to do over the last decade -- with mixed results.

There are, however, some indications that U.S. industry is trying to change and to adapt selectively from the competition. Ferguson identified a number of Japanese "operational components," including "just-in-time manufacturing, which requires close coordination between suppliers and producers; continuous improvement of production processes; flexible, small-lot mass production; a design philosophy emphasizing workability, quality, and frequent, incremental redesign; and a highly skilled, relatively flexible work force."

It is the last "operational component" -- a highly skilled workforce -- that is not present in the United States today. That, by itself, threatens America's ability to compete tomorrow.

MIT's *Made in America* study asserted that education for technological competence is crucial for raising the productivity of American firms. Its authors believe that to use technology effectively, workers will be required to develop their capabilities for planning, judgment, collaboration, and the analysis of complex systems. Learning, they state, especially on the job, must acquire new importance, and the primary responsibility for achieving this goal rests with individual firms, supported by government, labor and educational institutions.

While learning on the job may be the primary responsibility of individual firms, learning before arriving at the firm is the primary responsibility of the educational institutions. It is there -- in the pipeline -- that the real problem lies.

The educational establishment has quite a job to do, since Americans suddenly have to "learn to live in the world economy," as the MIT study puts it. "To compete successfully in a world that is becoming more international and more competitive, Americans should understand foreign languages, cultures and practices; shop internationally for technologies and materials, and look for the best industrial practices and benchmarks of productive efficiency."[10]

Today we are entering what many have called the "information-age" revolution. It engenders the same kind of worldwide upheaval that the industrial revolution precipitated in the middle of the eighteenth century.

The American response to the challenges of that earlier period is instructive, full of parallels that may apply today. According to a report by the National Academy of Engineering, which cites Nell Eurich's 1985 work, *Corporate Classrooms: The Learning Business*, "In the early days of the industrial revolution, the United States needed to develop a work force in sufficient numbers to operate the factories springing up in the eastern states. The United States was a nation of farmers and craftsmen, not mechanics and engineers, and the apprentice system, then the common method for learning a trade, was inadequate and impractical because large numbers of trained individuals were needed."[11]

The study goes on to say that "industry education programs of the mid-1800s and the turn of the century provided education for a purpose, namely, productivity . . . What began as industry's response to the real, practical need for a large pool of technically skilled

labor to operate machinery blossomed into what Eurich describes as a national obsession with industrial progress. Not only were corporate leaders committed to investing large sums of money in technical education and training, an insurance policy protecting the large capital investment already made in a valuable resource, but public and private interest in schools and higher education skyrocketed. A major force entered when Congress passed the Morrill Land Grant College Act in 1862, which encouraged states to establish colleges to train students in scientific farming, engineering, and military science. More than 70 state colleges and universities were established. The land-grant schools have in many instances metamorphosed into the nation's leading engineering universities."

Eurich cited the 1917 Smith-Hughes Act, aimed at public education programs in industrial arts, agriculture and domestic sciences, and the 1944 G.I. Bill of Rights (already cited) as examples of a national response to a perceived need.

In 1989, many of these historical models are sparking solutions to the present technical manpower shortage. For instance, in testimony to Congress given on May 11, the Aerospace Industries Association noted that "U.S. aerospace market success in the future will depend upon a work force capable of meeting the productivity and quality demands of a fast-changing marketplace. The future of the overall U.S. economy, in fact, will rest heavily upon its skilled labor force -- from production and service workers and technicians through scientists and engineers."

The AIA recommended a public/private sector partnership to prepare young people for work and to bridge the market adjustment process for those already in the workforce, including:

- Strong support of science, mathematics and language education and of technical programs throughout the American school system;
- Emphasis on the study of foreign languages and cultures;
- Closer coordination between basic educational curriculum and industrial training processes to ensure productivity of new graduates; and
- Tax incentives which encourage industry to invest in programs, tools and equipment for training in close alliance with universities and the public education system.

The American Electronics Association advocates a similar approach: "U.S. industry must commit to the continuing education of its workforce. While universities should assume the primary role as continuing education partners, industry must commit time and resources as an active partner. With females and minorities comprising 83 percent of new workforce entrants by the year 2000, U.S. industry must work with local schools and universities on special outreach programs to ensure the competency and interest of these key human resources." The AEA adds,"The United States can be the best, but excellence will come only if U.S. workers are given the training, the tools and the inspiration to make it happen."[12]

During the industrial revolution, industry did not necessarily treat workers as assets. Rather, they were treated as obligatory costs. Any benefits that accrued to workers based on industry's effort to train its laborers were, as Eurich points out, incidental. Today, that attitude cannot be tolerated. Industry, government and the academic community must act not out of selfish interest, but out of enlightened self-interest.

While our history is rich with models that have not gone unnoticed in many of the major studies of the past decade, such precedents must be updated for the 21st century.

Educators: Beyond Feudalism

Many recent studies have thoroughly examined the need to revamp different parts of the U.S. education system in order to beef up the technical skills and expertise of graduates of high school and university. However, few have dealt with the problem at the top. The global marketplace demands a new kind of thinking among business leaders if U.S. firms are to succeed and reestablish a competitive position globally. And such new and "global" thinking will require a different approach by

universities. Not only does the United States need more Ph.D.s in the sciences and engineering, but it also needs corporate leaders who understand and appreciate the world as it is.

That means that education at all levels must by definition be multidisciplined. Many of the studies we surveyed have pointed out the need to integrate more courses and instruction on foreign languages, geography and culture beginning at the elementary school level. Steps like that could help, but it is not yet clear whether Americans, especially academic and corporate leaders, appreciate the need for a much broader approach to education.

Back in the spring of 1987, a survey of large American corporations with at least one subsidiary abroad found that 76 percent of the senior executives agreed that American management lacked a global perspective.[13] According to an even more recent survey by Columbia University and Korn/Ferry International, when ranking skills that would be important to CEOs in the 21st century, only 35 percent of Americans considered experience outside the headquarters country to be very important compared with 73 percent of their foreign counterparts. Additionally, 62 percent of American managers thought an "international outlook" was very important, compared with 81 percent of Europeans, 87 percent of Latin Americans and 100 percent of Japanese managers.[14]

Marvin Cetron's book *Schools of the Future* points out that "an estimated 400,000 job slots for U.S. companies operating in foreign countries are lost each year for Americans overseas because they cannot speak the local language."[15]

Fortunately, a few signs can be detected that universities are becoming increasingly aware of the need to provide more training in international studies to future business leaders. In fact, nearly 40 universities across the country have developed programs with local school systems that are designed to improve the students' grasp of world geography, history and foreign affairs. Tom Collins, who heads LINKS (Linking International Knowledge with Schools), the George Washington University-based group, told a *Washington Post* reporter, "We want to improve the way they teach the world." According to the reporter, 'The project also echoes the urgency of a Southern Governors' Association report last year (1987) that called international studies 'the cornerstone to competition.' "[16]

Most of the focus of industry is still oriented toward developing technical skills alone. For instance, many businesses have created "corporate colleges." These colleges attract a talented pool of high school students because they can offer free tuition, a secure job, and training appropriate for the workplace, according to Herbert I. London, dean of New York University's Gallatin Division. He says that up to 30 of these alternative colleges may exist by the end of the century and number more than 100 in 50 years.[17]

Such alternative institutions may help business overcome part of its technical skills gap by compensating for inadequate technical training offered by educational institutions. But U.S. industry will still need a cadre of business managers with the vision to move the United States into the global marketplace of the 21st century.

According to a 1985 report of the Carnegie Foundation for the Advancement of Teaching, the dynamic nature of international business requires college graduates to be creative problem solvers: "Much attention has been focused on whether higher education is graduating a large enough pool of technically trained manpower . . . A more urgent question is whether graduates, in all fields, have the ability to be innovative, the will to take the necessary risks, the capacity for civic responsibility and the sensitivity to the international nature of the world to be effective in today's society."[18]

As we focus on the technical skills gap in the United States, we must also be aware that technical skills alone will not be enough to guarantee competitiveness. Moreover, while beefing up curricula at all levels helps to a certain degree, as one professor pointed out, the answer to the question of educational reform is not simply to recycle and reassemble the curricula of the 1950s. As he put it, "This is a changing society in a changed world; what

we decide our students ought to consider must reflect such changes, for as Emerson said it, 'the experience of each new age requires a new confession.'"[19]

To deal with the challenges of the next few decades, universities will indeed require a "new confession." In fact, the need to cross disciplines and integrate aspects of different fields like science and engineering, with other fields like foreign affairs, economics, languages and communications, will require a very different approach and philosophy. And that doesn't necessarily mean abandoning the classical liberal arts education or the traditional approach to the technical fields.

There should, however, be better integration at the undergraduate level between liberal arts and technical departments, designed to ensure that students from the various disciplines are exposed to, and provided the basic tools of, fields that they will not be able to avoid in the business world of tomorrow.

It also means that a serious restructuring of the feudal system that governs most university graduate and post-graduate schools must take place. Too often, graduate school departments jealously guard their turf and, in some instances, make it extremely difficult for students to cross the boundaries of different disciplines. Many academics resemble the soldiers of the crusades, only the issue here is not religious purity. It is, instead, the dogmatic purity of the particular department's degree requirements. Too often, those intrepid students who attempt to venture into unknown lands are labeled as heretics and peremptorily excommunicated from the fold. Indeed, at many universities today, the multidisciplinary programs that have been established exist in a no-man's land, deprived of the protection of the well-fortified academic departments and colleges within the university.

Some universities, however, are beginning to respond. While combined programs in fields like law and business have existed for some time, programs that consist of less traditional combinations are starting to appear. The University of Michigan, for example, offers a master's degree in Business Administration and Asian Studies and another in Business Administration and Industrial Engineering. Boston University accords departmental status to its University Professors Program, which allows graduate and undergraduate students to combine more than two disciplines into an integrated program of study.

Future business leaders will undoubtedly require expertise in several disciplines. But academics are still reluctant to break out of traditional molds and more effectively integrate theory and practice. A British journalist put it clearly: "Spinoza, Descartes, Hume and Schopenhauer were outstanding philosophers, but none spent their days in an ivory tower. The notion that scholarship is inconsistent with other things, such as the need to earn a living, is a 20th century invention -- and quite possibly a confidence trick." And, he added, "The separation of universities from other aspects of life, including business and commerce, is probably detrimental to all concerned."[20]

If the U.S. university system fails to adapt to the challenges of the 21st century, U.S. business managers will not only lack the technical skills required in a high-tech era, but they will also lack the vision and thinking required to be successful and competitive.

A Few Clouds over the Land of the Rising Sun

There is no question that Japan will remain a formidable adversary in the international technological competition. But even though Japan's legendary consensus-based approach toward industrial, social and foreign policies has been hailed as a model of how to get ahead economically, it is doubtful that the Japanese way could be successfully transplanted in the United States.

Moreover, as Wil Lepkowski of Chemical & Engineering News, pointed out last May, Japan has its own problems to contend with. "According to John P. Stern, who heads the Tokyo office of the Electronic Industries Association, Japan has several weak spots as it globalizes. Among them are overconfidence, inability to understand the political process in the U.S. and underassessments of

America's restorative powers, increased frustration of its educated work force, high cost of housing in Japan's major cities, desire of young people to get ahead faster and spend less time at the office, and unpopular tax reforms that could reduce work incentives of many employees."[21]

The other question that Americans must ask is this: do we even measure success in the same terms as the Japanese? As Charles Wolf Jr., dean of the RAND Graduate School, observed, "Virtually all goods and services are more expensive in Japan at the 135 yen-dollar exchange rate than the same or similar goods and services in the U.S. This," he says, "applies across the board: non-tradables (for example, land, housing, office space, hotel rates); services (cab fares, haircuts, laundry); and tradable commodities (cars, cameras, VCRs, food staples and beverages, shoes, tennis rackets, etc.). A survey last year by Japan's Economic Planning Agency found that, for a broad sample of 306 goods and services, prices in Tokyo were between 26% and 48% higher than those in New York."[22]

Wolf concludes that "Japanese consumers have been scantily served by Japan's performance in the world economy." These kind of conditions in Japan have also helped dissuade American researchers from accepting fellowships to work in Japanese labs that are sponsored by the Japanese public and private sectors.[23]

Yet, even if Japanese economic "achievements" at home pale in comparison to the space, freedom and quality of life enjoyed by the United States, sheer Japanese determination, discipline and resourcefulness will continue to animate the global economic competition.

Unfortunately, many American companies have not yet reached the point where they can go head-to-head with the Japanese and blunt Japanese attempts to dominate particular markets. While they have clearly led in the areas of research and development, American companies have failed to best the Japanese when it comes to translating R&D into products.

American business, however, is beginning

Research: A Forgotten Priority

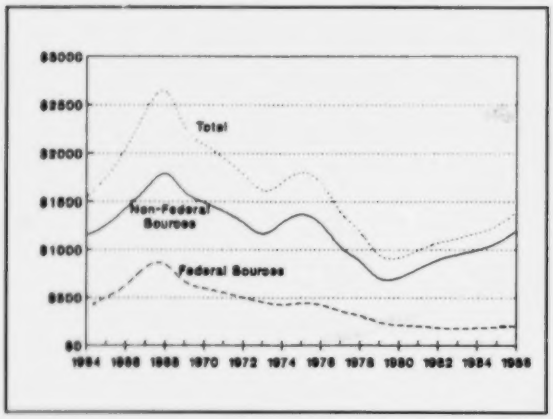

Figure 3.

Source: Council on Research and Technology

to apply some of the lessons of Japanese success. In an article in *Fortune*, Lee Smith pointed out that "in the past five years well over 100 consortiums have registered with the Justice Department to pool their resources for research into technologies ranging from artificial intelligence to those needed to overtake the Japanese lead in semiconductor manufacturing." Moreover, Smith adds that "over the same period Washington's attitude toward these cooperative enterprises has evolved from permissiveness to ardor."[24]

In 1984, Congress amended the U.S. Antitrust Act in order to encourage joint research. That opened the door to the formation of dozens of consortiums.

Such consortiums are important if America is to continue to hold its leadership position in research and development; however, a far more significant development is the recently established consortium that involves a production-sharing agreement between IBM and six other companies. The consortium will initially produce a new generation of DRAMs (dynamic random access memories) and then consider other products.

The new venture, called U.S. Memories, Inc., will, for the first time, involve shared manufacturing between competitors. That may raise some new antitrust questions, but

the trends suggest that the government will look upon this development favorably if the venture does not extend to marketing agreements that would deprive consumers of choices, according to Robert Pitofsky, dean of Georgetown Law School.[25]

This new consortium is significant because it moves the cooperative approach in industry from the R&D phase to the product phase. And, here, pooled resources may give U.S. companies the edge in a traditionally weak area for U.S. industry: moving breakthroughs in technological research to the market.

The combination of cooperation in the R&D area, where U.S. innovation and vision have always led the way, and cooperation in manufacturing, could be an unbeatable combination -- if America can produce the highly trained workers that U.S. industry will need in order to get into the game.

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TECHNICAL LABOR

Unskilled and Unprepared

The Demise of U.S. Education

Educational institutions have served as the foundation of industry and business, supplying the nation with motivated and skilled labor. Interestingly, today the United States spends more than any other nation for education while simultaneously ranking at the bottom of the industrialized world in terms of academic achievement.

Business leaders consistently complain about problems in finding and hiring adequately prepared workers. W. Jerome Baginski, director of education for the Tooling & Manufacturing Association in Chicago, stated, "I have 15 or 20 job openings that I can't fill. Some (association) members can't even add fractions, and they are training them starting with basic math."[1]

Louis V. Gerstner, president of American Express, cast the problem in a "good news-bad news" format. He wrote, "The good news is that American Express Co. will be hiring a minimum of 75,000 people over the next five years. The bad news is the company may not be able to find them. These are entry level jobs, yet AmEx finds applicants who can barely write, are ignorant of geography and unable to cope with simple mathematics."[2]

Clearly, the U.S. educational system is neither developing the innate abilities of the American people nor supplying the manpower the nation needs. The study by the Hudson Institute, *Workforce 2000: Work and Workers for the 21st Century*, summarized why the nation must solve its growing educational deficit problem.[3]

"Education and training are the primary systems by which the human capital of a nation is preserved and increased -- If the economy is to grow rapidly and American companies are to reassert their world leadership, the educational standards that have been established in the nation's schools must be raised dramatically."

Two recent reports -- *American Education: Making it Work*, by former U.S. Secretary of Education William J. Bennett, and *Building a Quality Workforce*, a joint effort of the departments of Education, Commerce and Labor -- indicate some bright spots have appeared in the U.S. education system since the dark days of the early eighties.

According to *Building a Quality Workforce*, " . . . American education has made some noteworthy progress in the last few years. Since 1980, combined average Scholastic Aptitude Test (SAT) scores have recovered 16 points from the sharp drop between 1963 and 1980. Nationwide, our schools have moved back into a more rigorous academic curriculum."[4]

In addition, "during the past 20 years American education generally seems to have succeeded in strengthening the basic skills of all of its students -- minority and economically disadvantaged children as well as the sons and daughters of more affluent parents," the 1988 International Assessment of Mathematics and Science stated. But, the report warns, "national assessments consistently reveal a weakness in higher-order thinking skills in all subjects."[5]

Education Secretary Lauro F. Cavazos adds that "the academic achievement of American

students remains far below its level in the early 1960s and well behind the performance of students in most industrialized countries."[6] Clearly, a great deal of work remains to be done.

The completion rate of high school students is only 75 percent. Furthermore, the high school completion rate among blacks aged 18 to 19 was 10 percent lower than the national average in 1986, and the completion rate for Hispanic youths of the same age was only 55 percent. These dropouts normally do not become productive members of the nation, and are not competitive candidates for jobs requiring even minimal skills.[7]

In the U.S. educational system today, institutional shortcomings also mean that even students with a diploma in hand do not necessarily hold an education in hand. Literacy statistics in the country are frightening. According to the Business Council for Effective Literacy, 27 million Americans over the age of 17 are functionally illiterate. Another 45 million are marginally literate, usually unable to function productively in a work environment.[8]

A 1986 study by the U.S. Census Bureau predicted that, at current rates, functional illiteracy in the general population of the United States will reach 70 percent by the year 2000. In terms of the work place, this means that 70 percent of the nation will be unemployable. Similar statistics are more often associated with struggling third world nations than with the world's economic leaders.

Increasingly, however, U.S. competitiveness depends on the math and science proficiency of the workforce. The report *Everybody Counts*, by the National Research Council, states, "Mathematics is the key to opportunity. For nations, it provides knowledge to compete in a technological economy. To participate fully in the world of the future, America must tap the power of mathematics."

Unhappily, the report concludes that "current mathematical achievement of U.S. students is nowhere near what is required to sustain our nation's leadership in a global technological society."[9]

An additional report conducted by the National Assessment of Educational Progress (NAEP) in 1988 showed that more than a quarter of 13-year-olds cannot handle elementary school arithmetic, and only six percent of 17-year-olds can handle algebra or multistep math problems. Furthermore, scores for blacks and Hispanics lag 7 to 11 percent behind those of whites.[10]

Science, for its part, drives technological innovation and is essential to developing the skills necessary to comprehend the work environment. This includes the ability to analyze findings, draw conclusions and, ultimately, to solve problems. As reported in *A World of Differences: An International Assessment of Mathematics and Science*, "only 42 percent (of U.S. students) can use scientific procedures and analyze scientific data."[11] That means that 58 percent of our students are not capable of solving many work-related problems.

Finally, U.S. vocational schools, which should be feeding entry-level workers into in the re-emerging manufacturing firms, are also failing to equip students with sufficient skills. As businesses attempt to regain their competitiveness in the area of manufacturing, business owners are complaining loudly about the inability of schools to keep pace with their requirements. Ronald W. Sandmeyer, president of Sandmeyer Steel Company in Philadelphia, notes, "There aren't many (vocational) schools training machinists or sheet-metal workers or press-brake operators or drill-press workers."[12]

"Preparation of people in technical fields ought to get just as much emphasis as students engaged in college preparation," Frank Mensel, an official with the Association of Community College Trustees and the American Association of Junior and Community Colleges, told a *Washington Post* reporter. "Unfortunately, education has a history of treating vocational education as a stepchild or a dumping ground."[13]

What About Tomorrow?

As technological change moves rapidly along, students will need to master higher-level skills in order to fill the job requirements of the next century. Employers will continue

to clamor for improved efficiency and flexibility among employees.

According to Gerstner of American Express, "The deficiencies go beyond the traditional skills. Too many young job seekers are also deficient in fundamentals such as teamwork, initiative, problem-solving, adaptability, even simple communication among themselves."[14]

Increasingly, workers will need to be able to use information, make decisions and solve problems in a computer-operated, mathematics-based, information-dependent society. The traditional three "Rs" will no longer guarantee success. It is not enough anymore for workers to be able to read single-paragraph instructions, operate simple machinery or compute basic calculations.

According to the Hudson Institute report, *Workforce 2000*, "Assembly line workers in many manufacturing plants are learning statistical process control, a system that is beyond the reach of those without a solid grounding in mathematics. Before advanced technology, (factory workers) did not have to think as much."[15]

Statistically, this implies that the majority of new jobs will require some post-secondary education; today only 22 percent of all occupations require a college degree.[16]

The *Wall Street Journal* summed up the risk: "A serious labor shortage is emerging for skilled blue-collar craftsmen ranging from machinists and electricians to shipbuilders and bricklayers. That shortfall, at aerospace companies, defense contractors and construction concerns, could damage American industry's efficiency and could encourage more manufacturers to move operations to foreign nations where workers are plentiful. And because skilled blue-collar craftsmen are considered crucial to the nation's defense industry, more and more executives worry that the U.S. couldn't respond quickly to an international crisis."[17]

Exploiting Untapped Resources

As worker skills plummet, the emerging demographics of the nation could add momentum to the fall. The workforce will grow more slowly than at any time since the 1930s, progressively shrinking the labor pool of qualified employees.

To cope with the dwindling labor pool, industry will attempt to meet its demands by increasing automation. Even now, companies are replacing single-purpose workers and machines with multi-purpose workers and machines. Consequently, fewer workers will be needed, but those hired will require increased technical skills to operate a variety of machines and comprehend the overall manufacturing picture. These facts, when considered in conjunction with the downward spiral of worker competence, foreshadow a dismal future for U.S. industry.

The study *Workforce 2000* has charted future demographics extensively. As the overall labor pool shrinks, women and minorities will grow as a larger share of the workforce, while the current majority -- white males -- will decline. Of the 25 million people expected to join the labor force in the near future, 85 percent will be women, minorities and immigrants. Women will comprise approximately

Labor Pool: Entering New Waters

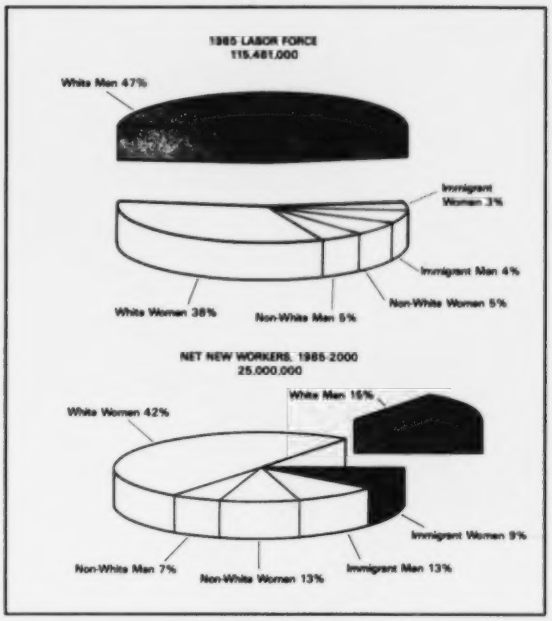

Figure 4.

Source: U.S. Department of Labor. Reprinted with Permission from Task Force on Science and Technology

three-fifths of new employees in the work place between 1985 and 2000. And minorities will comprise 15 percent of the workforce by 2000.[18]

If present educational trends persist, these demographics could spell big trouble, since dropout rates are substantially higher and literacy rates are substantially lower for minority groups. Furthermore, women and minorities have shown far less competency and interest in mathematics and science at a time when those areas will be omnipresent in tomorrow's work place.

It is important, however, to remember that the increased numbers of women and minorities in the workforce can be viewed either as a pending handicap or as a potential resource. Black women, for instance, have shown a consistent increase in high school completion.

And it is generally agreed that the lower levels of competence among minorities and women in math and science are not caused by some innate deficiency. Instead, it is the result of structures and attitudes that reinforce stereotypes and discourage these groups from pursuing technical studies. These sectors of society must be viewed as primary contributors to the nation's technological future.

The Skills Gap and America's Slide to Second Place

The educational demise of the United States represents an unnecessary waste of human potential. The consequences extend far beyond the classroom into every business, factory and office in the United States. As succinctly stated by former Commerce Secretary William C. Verity, "We have discovered we have a problem scarcely imagined a few decades ago -- the problem of hiring new entrants into the labor force who are capable of performing the work they are hired for."[19]

The incapability of schools to meet the technical labor demands of the nation has been dubbed "the skills gap." What it implies for American industry and business is a steady erosion of the ability to compete with foreign sectors.

The Aerospace Industries Association laments that "the pool of new workers for high technology industries such as aerospace -- which employs a considerable number of technicians -- may not be as large as in the past. Just as worrisome, applicants for jobs may not be as qualified as necessary."[20]

For U.S. firms nationwide, the shortages means unfilled positions; for New York Telephone Company, "84 percent of applicants from New York City failed their entry-level examinations. From January to July 1987, only 3,619 of 22,880 applicants passed the examinations intended to test skills including vocabulary, number relationships, and problem solving for jobs ranging from telephone operator to service representative."[21]

In order to fill some of these vacancies, U.S. companies have been forced to take on the responsibility of training their employees in basic skills, increasing their costs and undermining their ability to effectively compete in the international arena. According to the report, *Building a Quality Workforce*, "Currently one out of three American corporations provides some form of basic skills training for its employees. An American Society for Training and Development study predicts that American industry will have to spend as much as $25 billion yearly on remedial education."[22]

It is also impossible for businesses to remain competitive when product quality drops or productivity slides due to the incompetency of their workers. An article in the *Training and Development Journal* estimates that "the cost of functional illiteracy to American business in lost productivity alone is difficult to measure," but "conservative estimates range in excess of $6 billion annually."[23]

For example, the study *The Bottom Line* says, "In a major manufacturing company, one employee who didn't know how to read a ruler mismeasured yards of steel sheet, wasting almost $700 worth of material in one morning." Compounded daily, similar problems and errors eventually resulted in the loss of millions of dollars by the company.[24]

When applied to the national security arena, the erosion of the technical labor base translates into a state of military unpreparedness. According to Paul Kennedy, 'The most critical

constraint upon any surge in wartime production will be the number of skilled craftsmen -- which causes one to wonder about the huge long-term decline in American blue-collar employment, including the employment of skilled craftsmen."[25]

Furthermore, the 1988 Air Force Association report, Lifeline in Danger, noted that "the decline in manufacturing and technology leadership has had a most harmful effect on the nation's defense posture. Along with fears of a *future* loss of technological leadership, the United States must also be concerned about its *current* ability to respond to a national emergency requiring the mobilization of the defense industrial base."[26]

Pearl Harbor provoked the nation once during a national emergency. But at that time, Americans possessed enough skills to meet the challenge. Critics maintain, however, that if Pearl Harbor occurred today the underskilled, undereducated workforce probably would not be able to respond to the country's call.

Any complex work that involves decision-making and knowledge-building -- the work of factory technicians using advanced manufacturing technologies, of design and production engineers, or of research scientists -- adds to the nation's accumulated skills and experience. Our economic future and national security are served by developing a large team of technologically skilled, capable workers within the nation. Consequently, the skills gap has implications beyond business needs. For our nation, it implies a steady slide from first place in the world standings to second place or worse.

Currently, U.S. competitors are doing a superior job of training and educating their youth. According to the *Mathematics Report Card* conducted by the National Assessment of Educational Progress, the average Japanese high school student consistently does better at math than the top 5 percent of Americans.[27] Furthermore, as determined by the 1988 study A World of Differences, when compared against South Korea, the United Kingdom, Ireland, Spain and the Canadian provinces, U.S. students scored in the lowest-

Competitors Outdistance U.S. Students

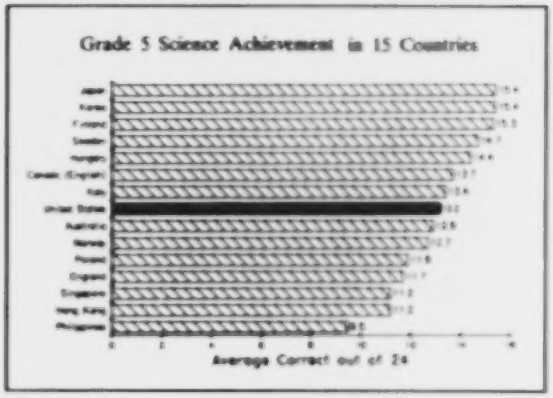

Figure 5.

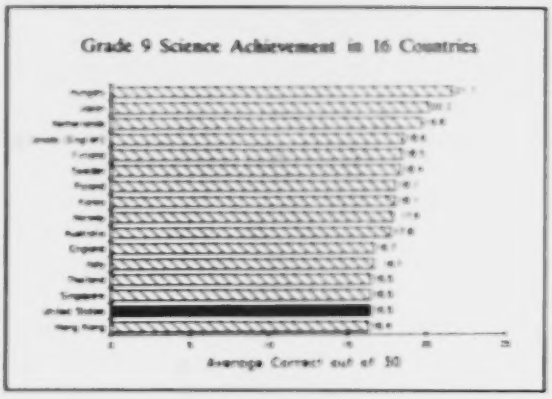

Figure 6.

Source National Science Foundation.
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ranking tier for both math and science; Korea was at the top in both fields.[28]

Paul Gray, president of the Massachusetts Institute of Technology, summarized the situation: "Our national performance in math and science is sadly diminished compared with nations we think of as competitors in national markets. In the latest affirmation, once again we end up at the bottom whenever someone does a comparison."[29]

Education Secretary Cavazos complains that high school students in the United States take an average of 2-1/2 years of science, while Soviet students, on average, take six years of biology, five years of physics and

four years of chemistry. West German and Japanese students have equally intensive science curricula. Gerald Wilson, dean of engineering at MIT, says, "Typically, the majority of students stop taking science and math courses when they can, usually at the end of their freshman year (and) often as early as the eighth or ninth grade."[30]

H. Ross Perot summarized the state of U.S. math and science curricula in a 1988 *Washington Post* op-ed piece: "We have diverted our schools from places of learning to places of play at a time when our international competitors have been deadly serious in pursuing academic excellence in their public schools. The typical high-school graduate in Japan is more knowledgeable than half of our college graduates. The typical Russian student studies physics and algebra for five years, calculus for two. Just hearing that," he adds, "would give the typical U.S. high school student a No. 4 migraine headache."[31]

On any international scale, the United States must be compared against its major trade and economic competitors. Gary S. Becker, University Professor of Economics and Sociology at the University of Chicago, states, "Schools in Japan and the other successful Asian countries emphasize mathematical and other technical skills demanded by modern industry. It is not surprising that Japanese and Hong Kong students placed near the top and U.S. students were close to the bottom in uniform mathematics tests given in 1984 to 12th-graders in more than 20 countries."[32]

The good news is that the American spirit and innate American talent still exist – it is just a matter of properly tapping into them. As stated by Harry Campbell, senior assistant technologist at TRW Inc., "One of our concerns in a high-tech industry is that there are kids out there who have talents but who are getting lost in the system."[33]

Slowly, our society is beginning to reclaim those lost children. "Those who drop out of high school later return to school or pursue an 'equivalency' certificate. Of all Americans between the ages of 25 and 29, 86 percent have completed four years of high school. For minorities, that figure has jumped from 77 percent in 1980 to 84 percent in 1986."[34]

As Jeff Bingham, administrative assistant to Senator Jake Garn, stated at the 1989 National Aerospace Symposium for Educators, "We have the values and the limitless potential to take mankind to his ultimate abilities." We have done it before and we can do it again. The obvious question, however, is, "will we?"

A Nation at Risk of Letting Down its Defenses

The mounting technical manpower crisis is pervasive throughout the United States and leaves no field untouched. Perhaps the area most threatened by the impending crunch is the defense establishment, including the Department of Defense, the armed services and the defense industries. This sector could well bear the brunt of the crisis.

The availability of scientists, engineers and technicians to work in the Department of Defense (DoD) and the armed forces is directly related to employment trends in private industry. For instance, when civilian industry experiences layoffs or hiring cuts, DoD and the services usually benefit and are able to attract adequate numbers to meet their needs. The National Research Council reported that placement officers in the defense sector found that defense employment expanded in early 1986 when some civilian industries experienced cutbacks.[35]

On the other hand, if there is a large unmet demand for technical employees in the civilian sector, defense needs usually suffer since the defense establishment is unable to compete with private industry's higher salaries and superior benefits.

The 1988 Department of Defense White Paper, *Task Force on Human Resource Management in Science and Technology: Year 2000*, indicates that the "double decline in the number of entrants to the work force, and the participation in S&T (science and technology) degree programs, will affect both civilian and military recruitment as we compete with industry for a declining number of people at our traditional target of entry-level professionals, while at the same time our pay and

benefits become increasingly noncompetitive. If left unchecked, the Department, because of a lack of an adequate supply of qualified and competent engineers and scientists, could suffer a degradation of its ability to respond to technological change, and its vital mission of National Defense."[36]

For its part, the defense industry is experiencing the same kind of shortages as other high-tech industries. *Aviation Week & Space Technology* reports, "The U.S. is facing a shortage of engineers at all degree levels that is being fueled by shifting demographics and reduced interest in engineering by college-age, native-born Americans. If it develops, this shortage could topple the U.S. aerospace and defense-related industries from the dominant position they have exerted on the worldwide defense market since the end of World War 2."[37]

Statistics from 1985 indicate that approximately 20 percent of all engineers were working in the defense area. Sixty-two percent of aeronautical engineers and 30 percent of electrical engineers were working on defense projects.[38]

According to the National Research Council, "DoD spending affects 14 percent of the Nation's entire S&T workforce. Furthermore, the U.S. Office of Technology Assessments (OTA) has postulated one model which estimates that for each $1 billion (1983$) of DoD spending there could be an increase in demand for 1,000 additional S&T personnel if the money is spent on procurement and 4,000 additional S&T requirements if the money is spent on research and development."[39]

The problem in a nutshell: "The DoD can expect an increased demand for S&T professionals, caused by turnover, technological advancements, and skills shifts, and can expect that the increasing demand within the Department, and in the general labor market, will outstrip the anticipated growth or supply of these skilled professionals by the year 2000. The Department will be facing a 25 to 30 percent increase in costs related to its investment in employee education and training caused by the pace of change and the learning needs of its employees. The gap that is projected between the supply and demand for S&T personnel, both within the Department and in the general labor market, will impact on the Department unless actions are started now."[40]

As former Secretary of Defense Frank C. Carlucci stated, "We need the help of the education community and industry to correct the nationwide technical illiteracy that is weakening our defense. Even the most well-designed and cost-effective weapons system program is useless without skilled craftsmen building sophisticated military equipment in our factories."[41]

Quality has always been the cornerstone of Western defense. Carlucci stated, "To a large extent, we've offset quantity with quality. In part, that means we rely on smarter soldiers and officers, well-trained and well-schooled in military tactics and strategy."[42]

At present, the defense establishment is facing the same harsh realities as the civil sector. "DoD cannot avert the demographic facts and their impact on human resources. We will operate in an environment of increasingly more complex jobs," the DoD White Paper concluded.[43] The situation is exacerbated by budget cuts, since defense cuts could ultimately entail cuts in manpower, thereby intensifying the demand for a highly competent, qualified and adaptable workforce.

Defense contractors are dealing with some of the shortfalls by placing more emphasis on automation. For example, as the aerospace industry experiences manpower reductions, "plans for military aircraft companies are generally moving in the direction of computer automation of manufacturing support functions and the computerized integration of all factory activities."[44]

All these trends combined threaten national competitiveness, since a great deal of technological innovation grows out of weapons systems development. "It is also important to recognize that there is often no sharp division between technologies related specifically to our defense effort and those with a range of applications far beyond it," stated Carlucci.[45]

Others disagree. For instance, Judith B. Reppy, a Cornell University economist, con-

tends that "97 percent of military R&D spending goes not for basic science that can yield a spectrum of benefits, but for weapons development and testing -- work that is of little use in the civilian sector."

But either way, R&D spending is definitely greatest in the defense sector. Therefore, declines in the technical competency and/or numbers engaged in these fields threatens the U.S. technological edge.

According to the National Governors' Association, "Federal agencies spent approximately $60 billion on research and development in 1988. Nearly 68 percent went for defense, up from 55 percent in 1981. Outside of defense, aerospace and health, federal agencies spend little on applied research and development."[46]

The Department of Defense requires a large number of qualified scientists and engineers in order to function adequately. The 1988 White Paper reports DoD's latest figures: "Of the one million civilians DoD employs, approximately 10 percent are scientists and technologists (S&T)."[47]

Like other sectors, many employees, from secretaries to mail clerks, increasingly require advanced skills in computer and information technology.

The armed services also need extensive numbers of highly qualified recruits. According to the Defense Department, of its two million members in uniform, 750,000 are strictly technicians requiring a sound background in high school mathematics and science. Furthermore, the daily work environment of military personnel mirrors the changes taking place in the civilian work sector with marked increases in the use of computers and communication equipment. The old image of the basic recruit who dropped out of high school, but could still function in the armed forces, no longer applies. Those who are not qualified when they enter need to be trained extensively by the services, increasing overall costs at a time when budgets are tighter.

The Army, Navy and Marine Corps all recruited fewer volunteers in the top three mental categories in the first half of fiscal 1989 than in the same period in fiscal 1988 and were forced to fill their ranks with lower-scoring recruits.[48]

A Navy spokesman made the point at a symposium for educators sponsored by the Aerospace Education Foundation, from June 22 to 25, that the "technical requirements of the Navy are expanding so much that by the year 2000 we will need every graduating student from the high schools."

The officer corps is also faced with shortages of qualified applicants. According to the Director of Public Relations for the Air Force Academy: "Only 2 percent of U.S. high school graduates in 1988 had taken courses needed to qualify for entry consideration by the Air Force Academy . . ."[49]

Even if the United States continues to succeed at producing the world's most sophisticated weapons systems, the armed forces may not have the skilled personnel to operate them. In that case, the United States would have let down its defense -- by default.

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TECHNICAL PROFESSIONALS

Scarce and Unqualified?

Carrying the Ball into the 21st Century

Inevitably, the decline of primary and secondary education has affected not only the levels and quality of the technical labor force, but also the nation's technical professionals. With the deterioration of secondary education, the average level of engineering education has declined as well. This decrease is occurring at a time of geometrical growth in the scope and technical knowledge required to practice engineering successfully, further eroding the United States' competitive edge.[1]

Indeed, the technical manpower shortfall is pervasive at all levels of the industrial pyramid, from labor on the shop floor up to CEOs in corner offices. College students and professionals, while better educated than drop-outs or high school graduates, still consistently rank behind Europeans and Asians in educational standards. At the professional level, inadequately trained Americans scientists and engineers -- the technical professionals who will carry the nation into the 21st century -- represent a looming threat to U.S. global competitiveness and national security.

Historically, the United States has always produced the world's best scientists and engineers, the leaders in technological discovery and invention. Currently, the United States still leads in research and development, but is falling behind in technical production and marketing. As Karen Elliot House of the *Wall Street Journal* wrote, "Many businessmen who envy Japan's technological prowess and marketing might remain confident that the high-tech battle is far from lost. One reason is America's pre-eminence in the realm of pure science where technologies are born."[2]

In terms of economic competitiveness, however, the United States has relinquished the lead. In many sectors -- including computers, semiconductors, superconductors, electronics and precision optics -- the United States is rapidly losing ground in the global race. In fact, in 1986 the U.S. balance of trade in high-technology goods was negative, for the first time, constituting a trade deficit.

The United States has just not met the grade when it comes to effectively producing and manufacturing high technology products. According to Robert White, president of the National Academy of Engineering, "America is probably the world's greatest innovator nation, but we don't have the ability to capture the benefits of those scientific discoveries."[3]

In order to recapture the competitive edge and maintain our national security in the future, the technical professionals of the United States must once again become the overall leaders in their fields.

The Numbers Game: Professionals in Demand

There is a persistent debate over whether the United States will be able to field an adequate team of technical professionals to compete effectively in the global marketplace of the future. Current shortages at Department of Defense laboratories are already severe. Given current shortages and the dwindling numbers of new engineers and scientists entering the workforce, combined with their

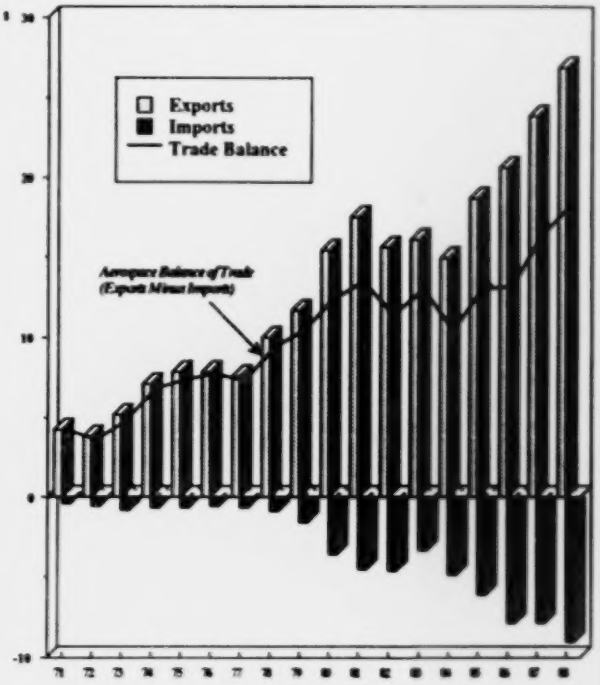
Aerospace Industry Maintains the Edge

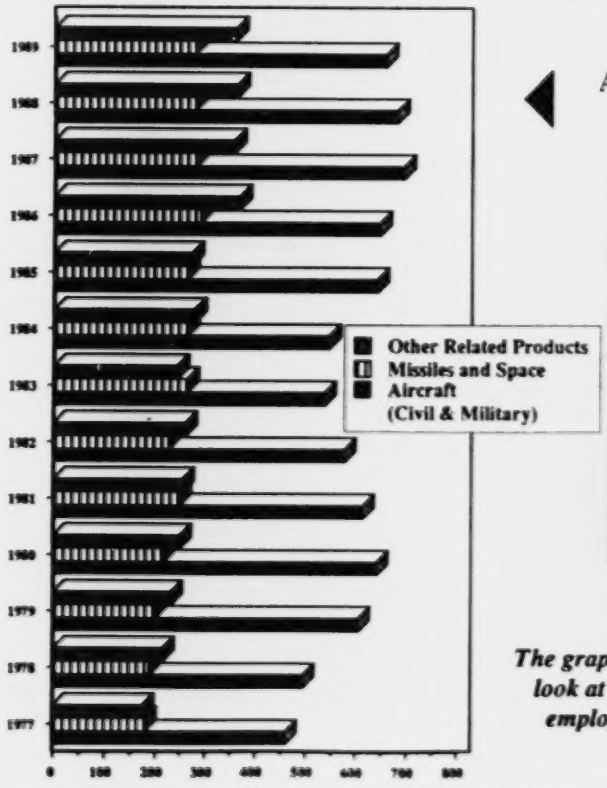
U.S. Aerospace Exports, Imports, & Trade Balance

Billion$ of Dollars

Year	Exports	Imports	Trade Balance
1971	$ 4.2	$ -0.4	$ 3.8
1972	3.8	-0.6	3.2
1973	5.1	-0.8	4.4
1974	7.1	-0.7	6.4
1975	7.8	-0.7	7.0
1976	7.8	-0.6	7.3
1977	7.6	-0.7	6.9
1978	10.0	-0.9	9.0
1979	11.7	-1.6	10.1
1980	15.5	-3.6	12.0
1981	17.6	-4.5	13.1
1982	15.6	-4.6	11.0
1983	16.1	-3.4	12.6
1984	15.0	-4.9	10.1
1985	18.7	-6.1	12.6
1986	20.7	-7.9	12.8
1987	23.9	-7.9	16.0
1988	26.9	-9.1	17.9

Source: U.S. Department of Commerce
International Trade Administration





Aerospace Industry Employment
By Product Group

In Thousands

Year	Aircraft	Missiles & Space	Other Related Products
1977	461	183	176
1978	495	189	216
1979	603	200	232
1980	641	218	248
1981	612	250	254
1982	575	227	260
1983	538	262	244
1984	545	262	277
1985	641	262	272
1986	646	287	367
1987	695	279	354
1988	679	277	361
Outlook for 1989	656	277	357

Source: AIA Research Center

The graphs and tables pictured represent a statistical look at aerospace in terms of orders and backlog, employment, and trade.

Figure 7.

Source: Aerospace Industries Association

lower skills, the problem can only worsen. Across the board, the DoD laboratories have had difficulties in retaining qualified scientists and engineers, and in recruiting new ones.

The Naval Research Laboratory in Washington (with 1,430 scientists and engineers) was unable to fill 39 percent of its requirements in the late 1980s. The Air Force and Army had similar experiences. Navy R&D centers also found that new hires in science and engineering generally had lower grade point averages than in the past.

Some of these difficulties experienced by DoD labs may be the result of inadequate pay and benefits compared with industry. But the shrinking pool of talent and lower skill levels also contribute to the erosion.[4]

On the other hand, studies by the Office of Technology Assessment, including *Demographic Trends and the Scientific and Engineering Work Force*, conclude that while particular scientific and engineering segments may experience shortages of labor, no pervasive evidence has been presented to conclude that a debilitating shortage is close at hand.

"It is entirely possible that the supply of people trained in science and engineering will not decline at all, despite the drop in the college age population." OTA concludes, therefore, "that career choices and market forces have a greater impact on the supply of scientists and engineers than do demographic trends."[5]

Other reports, however, disagree with OTA's conclusions. Among these, *The Science and Engineering Indicators - 1987* conducted by the National Science Board, states that "in the 1990's, changing demographics may impose restraints on the supply of newly trained scientists and engineers . . . While it is believed that adjustments in enrollment patterns will be made in response to a growing demand for S/E (scientists and engineering) graduates, it is not clear that such adjustments will be sufficient to provide an adequate supply."[6]

The National Science Foundation forecasts that between 1989 and 2010, the nation will be short more than 700,000 scientists and engineers.[7] In addition, the National Academy of Science predicts a serious shortage of aerospace engineers -- specifically, a 40 percent decline in the number of aerospace engineering graduates when the demand will increase by 70 percent. Other sectors of the economy will experience shortages as well, including computer science, electrical engineering and physics.[8] Even OTA, despite its optimistic outlook, claims that "it is individual disciplines, especially those linked with high growth or defense-oriented industries, that could experience personnel problems in the future."[9]

That acknowledges the individual effects of shortages in key disciplines. If, for instance, a high-tech company is unable to hire qualified workers to remain profitable, it matters not to company management that the overall U.S. average supply is about adequate: in that company's eyes, the United States is experiencing a dire shortage in the disciplines it needs. To say the average supply is adequate while severe shortages affect individual sectors and companies is a bit like saying the Titanic's hull was basically adequate, with only a couple of holes.

If these predictions are correct, the implied consequences cannot be overlooked, mainly because the anticipated shortages occur in fields imperative to U.S. security. Deputy Secretary of Defense Donald Atwood calls the shortages "very serious" for DoD.[10]

The aerospace industry, currently operating under a trade surplus (mainly due to commercial jet transport sales), represents the single bastion of trade leverage for the United States, the springboard from which the overall U.S. trade deficit can improve. And the "high growth" industries cited by OTA will be the competitive playing fields of tomorrow, where the United States will face Japan, a single, integrated market in Western Europe and the burgeoning Asian economic powers.

The Complexion of Tomorrow's Professional

A 1988 report entitled *The Effects of Quality of Adjustments in Engineering Labor Markets* by the National Research Council concludes that "over the next 5 years, the college-age population will decline and its composition with

respect to gender and race/ethnicity will change toward groups with historically low rates of participation in engineering . . . Unless the traditionally low rates of participation in engineering by women and minorities can be reversed, the demand for engineers may have to be met using nontraditional sources."[11]

International Competition: Losing the Game

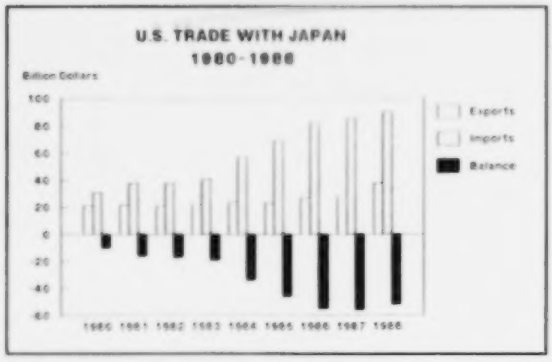


Figure 8.

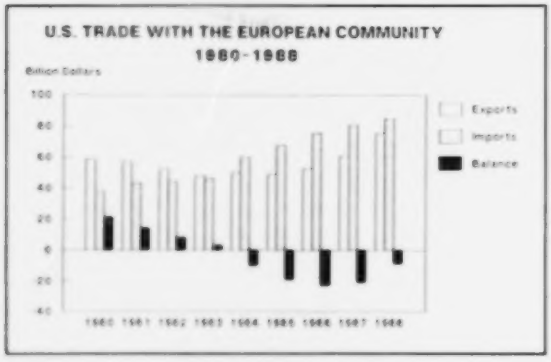


Figure 9.

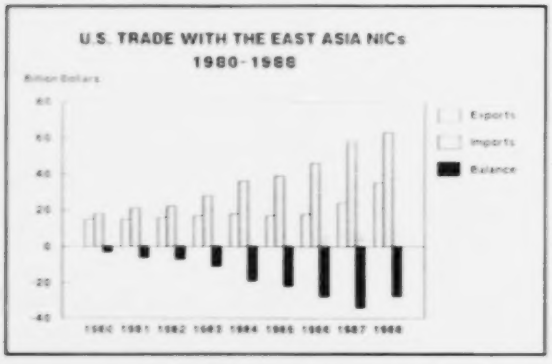


Figure 10.

Source: International Trade Administration

The Task Force on Women, Minorities, and the Handicapped in Science and Technology provides extensive statistics on women and minorities in technical fields. Blacks, who make up 12 percent of the American population, comprise only two percent of all employed scientists and engineers. In fact, the only minority group that is working extensively in technical fields is, not surprisingly, composed of Asian-Americans. While comprising only two percent of the U.S. population, Asian-Americans represent six percent of the science and engineering workforce.

Most striking of all is that women, who currently account for 51 percent of the U.S. population and 45 percent of the nation's workforce, comprise a mere 11 percent of all employed scientists and engineers. Engineering Manpower Commission data show that past improvements have gone awry. Even though the number of women enrolled in engineering schools climbed rapidly from 1973 to 1982, with freshmen enrollment of women peaking at 17 percent in 1983, the rate has since dropped to 15 percent.[12]

Women are also more likely to leave science and engineering positions once employed. The Task Force cites two predominant reasons for this: first, since they are usually paid 25 percent less than men in their fields, "they are more likely to lose self-confidence and feel less satisfied"; second, inadequate maternity leave and child care programs force women to make difficult choices. And if forced to choose, they most often refuse to enter the non-compliant technical fields.[13]

Suzanne Jenniches, president of the Society of Women Engineers, contends that "employers often do not give women the same opportunities for advancement as their male peers. They do not always believe in women's ability to stay the course and to succeed in the job. Until employers believe as much in the potential success of women as of men, women's salaries will continue to lag."[14]

Nevertheless, demand for these "non-tradi-

Women Avoid Engineering Professions

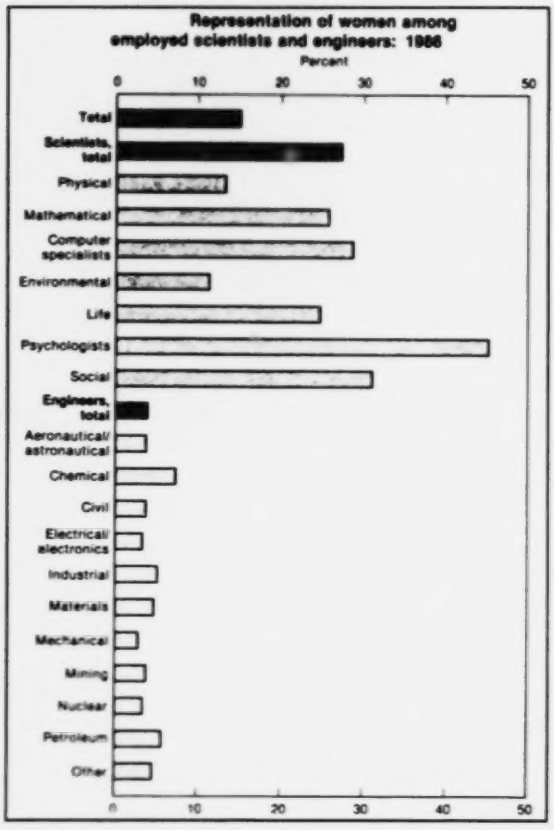


Figure 11.

Source: National Science Foundation

tional" groups -- including minorities and women – will be increasing in the future as the overall labor pool and college population decreases. Therefore, unless changes occur within the demographic distribution of technical professionals, the United States could continue to face a very real and pervasive shortage of scientists and engineers.

Adding to the demographic problem, interest has gradually decreased in both engineering and science baccalaureate programs. In 1978, 27 percent of entering freshmen indicated an interest in pursuing majors in technical areas; by 1986, only 24 percent expressed similar interest. This trend is expected to continue until at least 1990.[15] At the same time, attrition rates and retirements are expected to make the demand for entry-level professionals increase even more.

Some analysts contend that lack of interest in science and engineering fields is one result of changing market forces. The OTA report, *Educating Scientists and Engineers: Grade School to Grad School*, notes that "the drop in freshman interest could be interpreted as a delayed response to a market perceived as offering too few desirable positions for those graduating with a science or engineering degree."[16]

Other analysts, however, maintain that the problem may well be a symptom of a short-sighted society, more and more accustomed to instant gratification. According to James Williams, former dean of engineering at Carnegie Mellon University and current general manager of the Engineering Materials Technologies Laboratories at GE's Aircraft Engine Business Group, "Students read about the fantastic sums of money lawyers, investors and other businessmen are making, compare these amounts to the salaries paid to engineers, examine the engineering and business curricula and decide that too much effort has to be expended studying engineering for too little remuneration."[17]

Still others argue that the lack of interest in the field could well extend from the primary and secondary education levels, where incompetent math and science teachers do not foster the interest necessary to channel students into technical careers. Furthermore, archaic, obsolete and run-down university and research facilities add to the stigma of the dull, underpaid and uncreative science and engineering professional.

The cause of the shortage may be difficult to determine but the results are obvious. Many businesses have already experienced problems in hiring technical professionals. Sunday newspapers are replete with advertisements by engineering firms begging for professional employees to join their teams.

General Electric Co.'s Dr. Walter Butler, director of GE Labs, says that finding and keeping top quality engineers is his first priority task. In fact, GE maintains links with

Syracuse, Cornell, MIT and other engineering schools in order to facilitate recruitment. LTV Aerospace and Defense has set up independent research and development (IR&D) projects with universities to solidify ties and ensure a pool of talent for the future.

Other firms are employing retired professionals in a consultative, as-need capacity, and indicate they plan on retraining and holding on to older professionals longer. The National Science Foundation reports that 40 percent of all aeronautical and astronautical engineers were over 50 years of age in 1986, an increase of 23 percent from 1976.[18]

Even if the extensive shortage of technical professionals can be overcome, the quality factor represents another very real problem. Leif Soderberg, principal in the Cleveland office of McKinsey & Co., indicates that "America's Engineering Gap" means that U.S.

Technical Fields Don't Draw Crowds

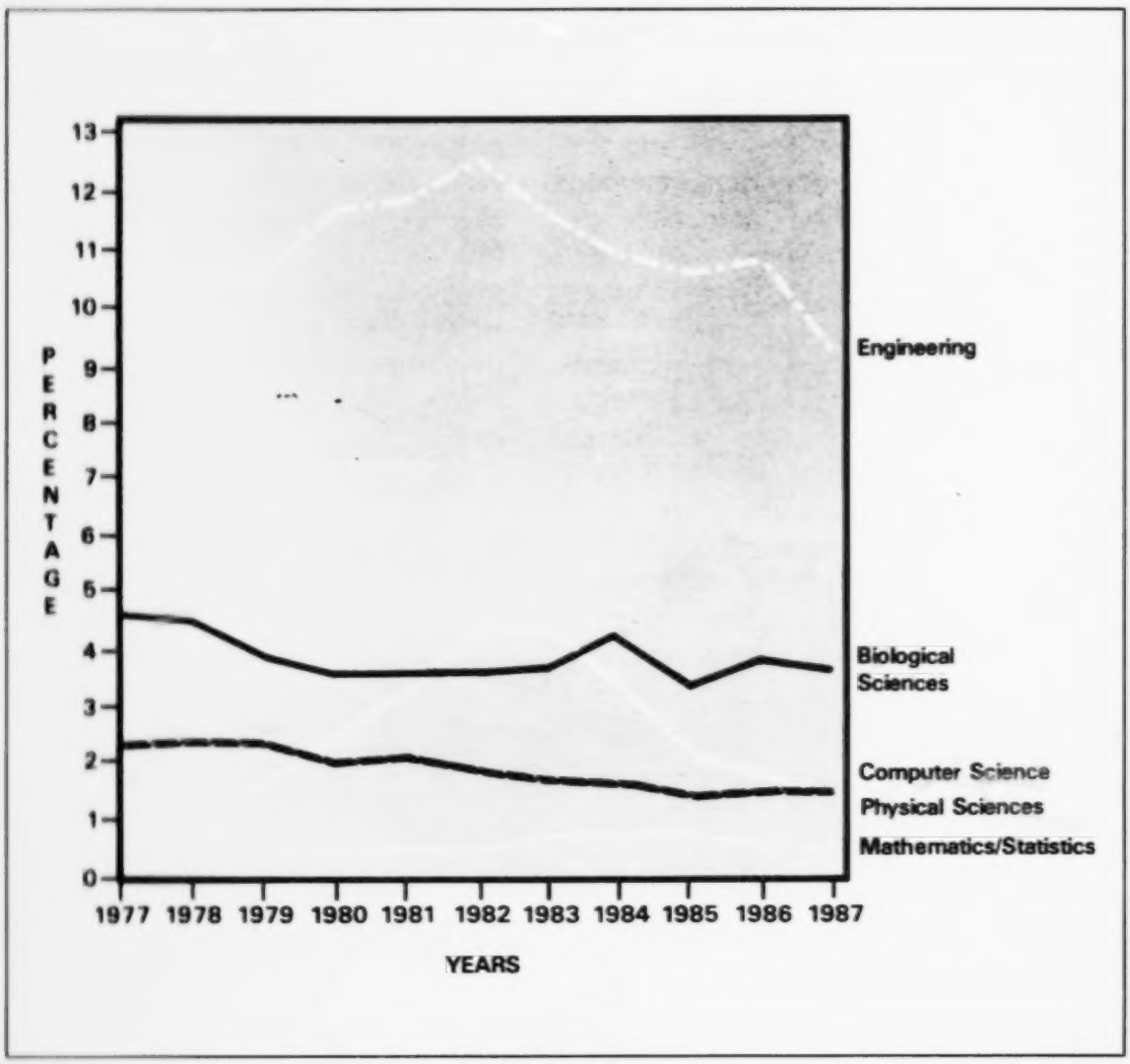


Figure 12.

Source: UCLA Higher Education Research Institute. Reprinted with Permission from Task Force on Women, Minorities and the Handicapped in Science and Technology.

"products are uncompetitive because they are badly engineered, not because we lag in new technology." Soderberg, like many managers in industry, believes U.S. technical professionals are not adequately prepared for the "real" world environment.[19]

Aviation Week & Space Technology reports that "General Dynamics and other aerospace firms are concerned that a growing number of entry-level engineers cannot write technical reports, fail to make effective presentations of their ideas or concepts and find it difficult to communicate with peers."[20]

Criticism of the crop of potential employees that universities and colleges produce often includes charges that entry-level professionals cannot write, cannot communicate verbally, possess an education that is more theoretical than applicable, and do not have an overall business perspective. This implies that U.S. engineers are not geared toward making the kind of high quality product that can stack up against the competition.

J. Michael Bowman, director of DuPont Co. Composites Division, states, "Engineers need to learn how to manufacture a new product, not only how to design it." He adds that engineering schools need to "produce architects instead of merely draftsmen. We need practitioners, not just theorists."[21]

According to the OTA, industry has taken on the task of training newly hired professionals to overcome the "overly theoretical bias imparted by engineering schools. Employers, by and large, do not expect new B.S. engineers to be fully competent for six to 12 months after hiring."[22]

An Aerospace Industries Association report, however, contends that the universities cannot be held fully responsible for the inadequacies of technical professionals. Heavy federal involvement in university research, and mini-

Business Predominant Career Choice

Figure 15.—Trends in bachelor's degrees conferred in selected fields of study: 1975-76, 1980-81, and 1985-86

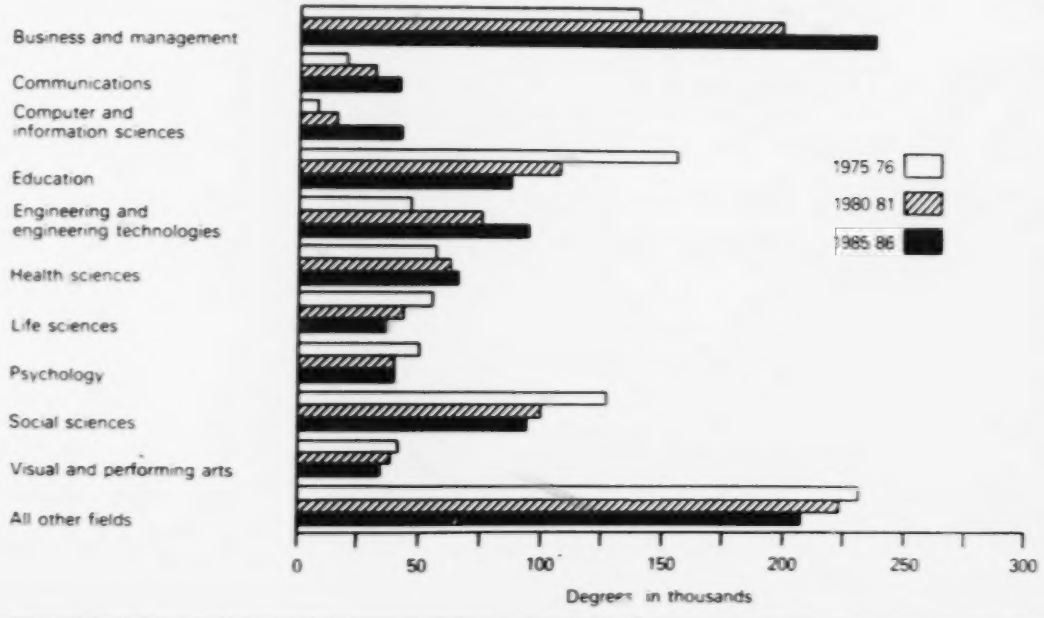


Figure 13.

Source: U.S. Department of Education. Reprinted with permission from the National Center for Education Statistics.

mal commitment of private funds to universities, has steered university interests toward government rather than industry concerns. Consequently, emphasis in universities leans towards theoretical research as opposed to the marketable and practical ends of engineering.[23]

Ph.D.s: Does Anybody Here Speak English?

Increasingly, at a time when Americans are losing interest in technical fields, foreigners are entering U.S. institutions and obtaining science and engineering degrees in mass quantities. This trend is especially evident at the doctoral level.

OTA's study reports that "the most fundamental recent development in graduate engineering education is the large foreign influence in U.S. engineering schools. Engineering and some fields of science, such as mathematics and physics, have long had significant numbers of foreign-born faculty, most of whom have become naturalized citizens. The influx of foreign students during the last decade, though, is of an unprecedented scale. More than half the engineering students in American graduate programs are foreign. Today, more engineering PhDs are awarded to foreign-born students than U.S. citizens. University faculties are even more heavily weighted toward non-U.S. citizens."[24]

In addition, the National Science Board reports, "Ph.D. awards to non-U.S. citizens have increased steadily -- In 1985, the percentage of total S/E Ph.D.s awarded to foreign-born students hit an all-time high at 26 percent, with individual field ratios reaching 55 percent in engineering and 26 percent in the physical sciences."[25]

The Aerospace Industries Association reports that "for aeronautical and astronautical engineering, non-U.S. citizens represented 38 percent of graduate enrollment and over 50 percent of doctoral candidates in 1986. Few of these students can take jobs in the United States because of visa and national security requirements."[26]

This is important since the aerospace industry is the United States' most competitive sector. Likewise, other companies in the defense fields, which will experience a professional labor shortage in the future, also cannot employ many foreign researchers and developers to fill the gaps because they do not qualify for the required security clearances. Deputy Defense Secretary Atwood sees this as a continuing cause for concern.[27]

OTA's reasoning for this trend: "Fewer and fewer U.S. citizens are willing to forego the lucrative salaries that new baccalaureate engineers (and some scientists) can obtain, in favor of several years of graduate student poverty that will yield them a few thousand dollars more in annual starting salary."[28]

The foreign doctoral growth in technical fields is having a profound effect on the way universities operate. For example, many institutions are now inclined to teach theoretical engineering, since many foreign-born professors have no industrial experience. Furthermore, at a time when the United States needs intensive recruitment of women into technical professions, the cultural attitudes of many foreign professors discourage women from doing so.

In terms of national defense, security procedures related to technology transfer make it nearly impossible for defense contractors and federal laboratories to collaborate with universities where there are high proportions of

Foreigners Dominate Doctoral Studies

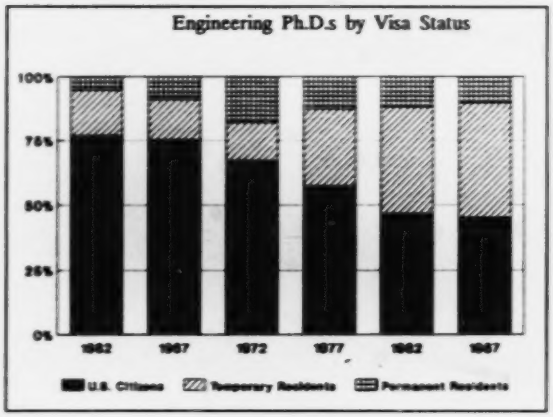


Figure 14.

Source: Council on Research and Technology

Science and Engineering Ph.D.s
Future Supply and Demand

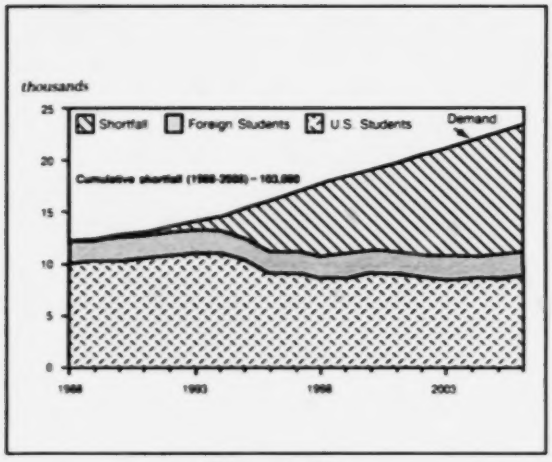


Figure 15.

National Science Foundation
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foreign graduate students and faculty. And because national security restrictions also limit recruiting these Ph.D.s for national defense projects, the pool of advanced technical professionals available to work in the Department of Defense or with defense contractors on specific weapons systems is severely limited.

Discounting foreign doctorates, it becomes apparent that there is a deficit in the numbers of qualified individuals required to teach the next generation of students. Consequently, the quality of tomorrow's workforce is also in jeopardy. The post-secondary institutions may need to recruit many of today's professionals into doctoral programs and teaching. But at the same time, there is intense competition between several segments of the country for these scarce and competent individuals, especially industry.

Quality Professionals: At the Heart of the Competition

While private industry is attempting to remain competitive in the technology marketplace, other sectors of society, equally important to U.S. national security, are competing for the technical professionals employed by industry.

Defense and academia need these employees. But industry has been consistently outbidding both the Department of Defense and universities with higher starting salaries.[29]

According to the *Washington Quarterly*, "One of the most important questions facing the U.S. military in the years ahead under all-volunteer conditions will be not whether it can recruit the required quantity of manpower but whether it can entice the required quantity with the required qualities to join."

Foster also says that "aptitude requirements in certain high-tech jobs currently would disqualify as many as 70 percent of the male population and almost 90 percent of all otherwise eligible women. As the population continues to shrink, competition to fill vacancies undoubtedly will intensify between the military, colleges and civilian employers – pay levels will have to be increased to keep pace with the civilian job market."[30] Under today's budget austerity, however, increasing military salaries is not a viable solution.

Finally, the competition over attracting qualified staff within private industry is cutthroat. While private firms can tentatively support increased salaries, they cannot necessarily support the benefit-bidding war waged to attract competent professionals. In order to recruit new employees, companies are forced to offer improved child care, expanded maternity leave, spouse hiring programs, relocation incentives, upgraded health plans and profit sharing. All these programs raise operational costs dramatically and ultimately decrease product affordability.

Recruitment efforts by defense contractors, which often have to persuade employees to move to high-cost areas, border on the creatively unique. Northrop, for instance, paid $2,000 bounties to its employees for steering the right talent to Pico Rivera, Calif. And Lockheed's bounty program, titled "Name that Star," rewarded recruiters with $1,000 to $2,000 for each new employee. During the time when competition for skilled workers in Southern California was most intense, Hughes Aircraft Ground Systems had the best

reward -- a grand prize trip for two to Monaco.

As with technical labor, the inability of educational institutions to meet the needs of industry hurts U.S. competitiveness. International competitors are doing better at fielding effective, technical-professional teams and are, consequently, overtaking the United States in some areas of the global economic race.

The 1985 study, *Engineering Employment Characteristics*, states, "Throughout the 1970s, Japan produced at least twice as many B.S. engineers per 10,000 population as the United States and on the order of 10 percent more in absolute numbers. From 1965 to 1980, the number of scientists and engineers employed in R&D increased 30 percent in the United States, 82 percent in West Germany, 131 percent in Japan, and 140 in the USSR."[31]

Vice President Dan Quayle cites additional statistics specifically related to U.S. aeronautical and space endeavors. "In 1985, the US graduated 78,000 engineers, only eight percent of our total graduates, while the Soviet Union graduated 335,000 – 39 percent of their total. Similarly, Japan, with half our population, graduated 72,000 engineers, almost 20 percent of their total graduates, West Germany 14 percent of their total, and almost half of France's graduates were in either science or engineering." And "The Soviets' great pool of engineering and scientific talent has enabled them to concentrate huge resources on innovative space-age technologies – especially those with space-based military implications."[32]

Summarizing the size of the United States' engineering force, the National Governors' Association reports that the "United States has a large number of scientists and engineers in its workforce, but given the size of our country, the difference is misleading. We are further behind our competitors when scientists and engineers are viewed as a percentage of the total workforce . . ."[33]

Beyond sheer numbers, the distribution of professionals also adds to or diminishes a nation's competitive strength. According to the report, *Engineering Education and Practice in the United States*, "Japan is clearly producing more technically trained people than the United States is." But the study continues, "It has been reported that only about half of Japan's engineers actually enter the engineering profession. The rest become civil servants or managers in industry. In fact, about half of Japan's senior civil servants and industrial directors are said to have engineering qualifications, a circumstance that must be contributing to that nation's industrial success."[34]

Comparatively, U.S. industrial leaders are drawn more from business fields than in the past. The National Science Foundation reports that from 1976-1980 engineers became increasingly more involved in production and analysis and somewhat less involved in management. Furthermore, "women were less represented in managerial jobs, reflecting both their more recent entry into engineering and, to some unknown extent, their lower level of acceptance by the profession."[35]

Aviation Week & Space Technology magazine reports that this trend is especially apparent in aerospace and defense industries. "The U.S. aerospace industry is increasingly being managed by senior officials with business degrees and backgrounds, rather than executives with technical backgrounds. – The trend is generally toward the MBA." For example, "Senior managers at Allied-Signal and UTC (United Technologies Corporation) – both large companies with international links – are much more likely to have advanced degrees in business than in engineering."[36]

For this reason, many students in the United States view engineering and science as a dead end; they do not consider these fields as stepping stones to business, management or government careers. Conversely, many in business, management or government positions do not comprehend the implications of technology and engineering on the global posture of the United States.

The MIT study, *Made in America*, notes, "Historically, business schools, including the Sloan School of Management at MIT, have not taught that technology or human resources are as important or central to the task of managing as finance, marketing, or other tradi-

tional disciplines of management."[37]

Militarily, the growing gap between the scientific training of Americans and their Soviet counterparts represents a growing danger to U.S. security. The 1988 Department of Defense annual publication, *Soviet Military Power*, has outlined the danger precisely: "As part of the United States' deterrent strategy, it relies heavily on technological rather than numerical superiority. Its strong technological position has always balanced sheer Soviet numerical advantages and thereby added to deterrence. -- Although the Soviets have, in the past, relied more on quantitative production to achieve military superiority, they are now emphasizing the acquisition of advanced technology to produce and deploy high-quality weapon systems and narrow the West's lead."[38]

As a nation whose defense inevitably relies on quality as opposed to quantity, the decrease in the quality of technical professionals must be viewed as a decrease in the military preparedness of the nation. The 1988 Defense Science Board study on the defense industrial and technology bases adds that "the effectiveness of our deterrent depends upon our ability to maintain this technological superiority and our adversaries' belief in that ability. When our ability is questioned, our deterrent is diminished and the threat of war increases."[39]

Robert A. Fuhrman, vice chairman and COO of Lockheed Corporation, and Robert M. Gardiner, senior adviser and former chairman of Dean Witter Reynolds Inc., state, "America's technological superiority has declined and many countries, including Japan and the Soviet Union, now challenge our leadership in technologies essential to defense and to our strategy of deterrence."[40]

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STUMBLING INTO THE 21ST CENTURY

Will Anyone Recognize the Workplace of Tomorrow?

The ability to adapt to change is a requirement for national survival in the future. Certainly the pace of technology development accelerates with each decade, carrying with it the absolute need to keep in step with the quickening tempo. For confirmation, one need only look back a short time. The Commerce Department estimates that approximately 90 percent of all scientific knowledge has been generated in the last 30 years. In the next 10 to 15 years, this pool of knowledge will double again.[1]

Industry and labor will have to face the realities of how and what to change in order to remain competitive in this maelstrom. David Kearns, CEO of Xerox, says, "Future jobs will be restructured about every seven years and work and learning will be inseparable."[2]

Workers and corporations will expect the U.S. education system to produce workforce entrants capable of coping with change, and of assisting in the continuing requirement for education and training. That means companies will expect educators to prepare people with the basic skills needed to enter the workforce, such as reading, writing and mathematics. The National Research Council notes, "Not only in mathematics but in every school subject, educators are faced with rising expectations for preparing the kind of work force the country will need in the future. Information-age technology will continue to grow in importance; pressed by rising international competition, industry will demand increased quality and increased productivity. The world of work in the twenty-first century will be less manual but more mental; less mechanical but more electronic; less routine but more verbal; and less static but more varied."[3]

The Bureau of Labor Statistics forecasts that more than half of all new jobs created between 1984 and the year 2000 will require some education beyond high school, and almost a third will be filled by college graduates.[4]

While the number of new jobs is growing, the customary sources of new workers are declining. Traditionally, the age group between 16 and 24 was a prime source. But that group is progressively shrinking as the diminished birth rates of the post baby boom era take effect.

The Hudson Institute projected the trends in these terms: the workforce will be older, with average age rising from 36 to 39 by the year 2000; workers aged 16-34 will decline from half the workforce to less than 40 percent; and 80 percent of new entrants into the workforce will be women, minorities and immigrants. Non-whites, women and immigrants will make up more than five-sixths of the net additions to the workforce between now and the year 2000. That means more entry-level workers will necessarily come from groups deficient in the basic skills.[5]

The Aerospace Industries Association considered the effects on its industry. "Over the next 20 years, 18- and 19-year-olds, a traditional source of new labor, will decline by 25 percent. The effects of the 'Baby Bust' are

beginning to be felt: the number of employees entering the U.S. labor market is at its lowest in four decades. As a consequence of these changing demographics, the average age of the total U.S. labor force is increasing -- a trend particularly noticeable in the aerospace industry. The National Science Foundation reports that 40 percent of all aeronautical and astronautical engineers were over 50 years of age in 1986; this was an increase of 23 percent from 1976."[6]

The problem, according to the AIA: "An aging workforce necessitates retraining and adjustment of adult workers in place of filling jobs with new young workers. Training involves job skills but also critical basic skills. One out of three major corporations already provides new employees with basic reading, writing and arithmetic courses. If current trends continue, American businesses will hire one million new people a year who cannot read, write or count."[7]

Minority workers will comprise 30 percent of the workforce by the year 2000, the Carnegie Corporation estimates. Karin Egan, program associate for Carnegie's program on science, technology and the economy, notes that minorities are "at the bottom rung of the ladder." She contends that it is imperative for the nation to train women and minorities in science, engineering and as technicians.[8]

And You Think It's a Jungle Out There Now?

Commerce Secretary Mosbacher told a Senate committee that the Federal government "needs to help U.S. industry build what Dr. Robert White of the National Academy of Engineering calls the nation's 'civil technology base,' the combination of basic technologies and skilled people necessary to help our companies compete in this increasingly competitive world." He emphasized that the need and authority are there, and it is time to "get on with the business of restoring America's technological leadership."[9]

Secretary Mosbacher addressed the question of future requirements for skilled workers. "We are not producing the type of professionals we will need to be competitive with

Japan Outproduces U.S. in Engineers

TABLE 13 Output of Engineering B.S. Degrees for United States and Japan: 1971, 1975, and 1980

	Engineering Degrees (B.S.) (thousands)		Engineering Degrees per 10,000 Population[d]	
Year	USA[a]	Japan[b,c]	USA	Japan
1971	50.0	55.9	2.44	5.30
1975	46.9	65.4	2.19	5.66
1980	68.9	73.5	3.1	6.22

NOTE: Initial tabulations provided by National Center for Education Statistics.
[a]National Center for Education Statistics.
[b]*Statistical Abstract of Education, Science and Culture* 1981 ed. Ministry of Education, Science and Culture, Japan.
[c]*UNESCO Statistical Yearbook*.
[d]U.S. Bureau of the Census.

Figure 16.

Source: National Center for Education Statistics. Reprinted with permission from National Research Council.

the rest of the world. According to a recent federal study, by the year 2010, the United States could suffer a shortfall of as many as 560,000 engineering and science professionals. Japan, with a population one-half ours, graduates twice as many engineers. And every year, well into the next decade, Japan will graduate 10,000 more engineers than we will. We have our work cut out for us."[10] (Figure 16)

But the schools and colleges that produce skilled professionals require qualified faculty members, and the trends and forecasts for engineering faculty are dismal. According to the Council on Research and Technology (CORETECH), since 1980 the engineering faculty vacancy rate has never fallen below seven percent. It has been as high as 10 percent. Currently (1989), over 1,400 engineering faculty positions are vacant. Fewer science and engineering Ph.D. recipients are staying to teach and conduct research, and one-third of the present faculty will retire by the mid-1990s. By the year 2000, just a decade ahead, CORETECH estimates that replacement demand for science and engineering faculty will grow from about 1,300 annually to about 4,400.[11]

Industry, government and the military will be competing with colleges and universities for ever scarcer qualified individuals. To cope with the demands, science and engineering candidates will have to come from non-traditional groups: women, minorities and immigrants.

Needed: A Long-term Vision

Consensus exists regarding the problems and challenges of the technical manpower shortages. But does similar unanimity exist regarding possible solutions? The answer: it does, in varying degrees of detail and specificity.

Deputy Secretary of Defense Atwood was cited earlier, stressing the very serious effects of technical manpower shortages on national security. Assessing industrial competitiveness in July 1988, the Department of Defense called the deficiencies in education and training at all levels "the most serious long-term problem facing the United States industrial base." In that same 1988 report, DoD noted the absence in recent years of a "fundamental examination of the quality or relevance of American educational systems (at all levels) specifically from the perspective of the needs of an advanced industrial economy. It said the DoD problem with respect to inadequate skill levels "is a component part of the national problem. The Department recognizes that long-term basic solutions are beyond the scope of its responsibilities and capabilities and urges that there be a national effort, beginning now, to achieve these long-term solutions."[12]

Norman R. Augustine, chairman and CEO of Martin-Marietta Corp., whose career includes both government and industry service, recommends "streamlining our society and our economy to compete more efficiently under today's conditions." Calling it "repairing the infrastructure," he advocates "first and foremost, upgrading our primary and secondary educational system – including longer school days and longer school years with strong incentives for teacher excellence . . . "[13]

Augustine also calls for a "broad, working partnership in this country that brings together the collective power of our government, our industrial sector, including labor and our academic community to 'out-compete' foreign nations targeting key industries" here. Among other recommendations, he suggests a greater emphasis in business on long-term objectives and less premium on short-term benefits and a capital gains tax inversely proportional to the length of time an investment is held.[14]

Members of the National Governors' Association agree that U.S. industry's vision must be expanded. They say, "U.S. industry's focus today is short-term; the quarterly profit and loss statement. Rather than viewing long-term investments in product development and improved manufacturing processes as assets, the financial markets consider them as expenses."[15]

The NGA says that governors have led the new wave of education reform in the United States, and that the states play a major role in higher education and support of research. They also encourage partnerships between state governments and businesses. As for the federal government, the governors say this: "The race is on. The competition is tough. To excel in this contest requires leadership at home. The federal government must exert its leadership and bring together all of the players to develop a national approach to this challenge. A national commitment on the part of industry, academia and government is central to realizing the nation's full potential in research and technology."[16]

The Council on Research and Technology also advocates that the federal government promote effective cooperation. Among other calls for action, it requests a "national assessment of current and projected work force training and retraining needs." CORETECH also suggests a national congress of state-level forums and institutions working on this problem be held before 1991. The purpose: to share, discuss and disseminate effective ideas. It also recommends federal incentives for state and regional forums to exchange information, and ensuring that immigration laws allow foreign nationals with the needed education and training to remain in the United States. Also recommended is a provision in major new federal scientific or technological projects for "direct investment in training and retraining of needed scientists, engineers and technicians so they will not be drained from other sectors."[17]

Endnotes

[1] *Building a Quality Workforce*, p. 9.

[2] *Ibid.*, p. 10.

[3]National Research Council, *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (Washington: National Academy Press, 1989), p. 11.

[4]*Building a Quality Workforce*, p. 10.

[5]Hudson Institute, *Workforce 2000*, pp. xx-xxi, Indianapolis, IN, 1987; fifth printing 1989.

[6]"Facts & Perspective," Aerospace Research Center, Aerospace Industries Association of America, Inc., May 1989, p. 1.

[7]Ibid.

[8]Address, "Expectations for Local Alliances," presented July 5, 1989 at the National Leadership Conference for Local Alliances, Vail, CO.

[9]Commerce Secretary Mosbacher, testifying before the Senate Committee on Commerce, Science and Transportation, May 9, 1989.

[10]Ibid.

[11]"Meeting the Needs of a Growing Economy: The CORETECH Agenda for the Scientific and Technical Workforce," Council on Research and Technology, Washington, DC, 1989.

[12]U.S. Department of Defense, *Bolstering Defense Industrial Competitiveness*, Washington, DC, July 1988.

[13]Norman R. Augustine, "U.S. Credibility and Viability in Worldwide Competition," remarks at the Conference Board Public Affairs Conference, New York, May 25, 1989.

[14]Ibid.

[15]National Governors' Association, *America In Transition, the International Frontier*, Report of the Task Force on Research and Technology, Washington, DC, 1989, p. 16.

[16]Ibid, p. 31.

[17]CORETECH, Meeting the Needs of a Growing Economy, p. 28.

CURRENT PROGRAMS

Finding the Trees in the Forest

Industry's High Stake in Education

At one time industry could simply pay for the quality workforce it needed. In fact, its approach revolved around the idea that if it could provide training, offer attractive wages, benefits packages, advancement and a bright future, career-conscious workers would follow. Today, this is no longer the case. Industry cannot guarantee itself a sufficient workforce simply by outbidding other sectors of the economy in the quest for skilled, educated individuals. The reason: these skilled and educated individuals simply do not exist, at least not in large enough numbers.

Not since America first became a leading manufacturing nation has industry had to be so concerned with the problems related to untrained and uneducated employees. Today, corporations spend billions on retraining workers who never learned the fundamentals in math and science or who have difficulty deciphering written materials.[1] Moreover, uneducated workers are less flexible and have a harder time adjusting to changes in their job position. Workers of the future will be required to perform multiple tasks and must be prepared for the computerization of many current duties.[2]

Like it or not, industry has had to work with, and more often work around, the deficiencies of the current education system. As the report *Building A Quality Workforce* suggests, "Skills deficiencies are costing American business monetarily, through waste, lost productivity, increased remedial costs, reduced product quality, and ultimately a loss of competitiveness." The report cites Metal Fab Corp., which estimated that it could save up to $1.2 million annually in wasted materials, supervision costs, and additional time spent on redoing orders if employees were better prepared in math and reading.[3]

The National Alliance of Business estimates that if industry's problem of having to continuously upgrade the skills of workers is not corrected, the $30 billion spent annually by corporations for worker training and retraining will increase dramatically and become an "insurmountable obstacle to U.S. competitiveness."[4]

Given these trends, industry reluctantly concluded that if American schools are going to turn out the next generation of scientists and engineers, industry is going to have to help direct that effort. As mentioned, certain sectors, such as the high-tech industries, which earlier preferred to distance themselves from primary and secondary educational issues, are now being called on to become active partners in the effort to improve the educational system.

Companies like Honeywell, Rockwell and GTE realize that without their help, the school systems will not have the instructors or equipment required to train students for careers in these technical fields. Consequently, they are joining round tables, task forces and advisory committees to ensure that the elementary and secondary schools are pursuing a curriculum that will both prepare and interest students in technical fields.[5] Companies are also opening up their facilities and releasing their personnel to work with the schools.

Through its Advanced Career Training Center in Downey, Calif., Rockwell International provides students with not only the exposure, but also the prerequisite skills to pursue a degree and eventually a career in science and engineering. Rockwell personnel and facilities provide students instruction and hands-on experience in a variety of technical fields. Over 100,000 volunteer hours have been expended by Rockwell professionals. Their efforts have helped approximately 35,000 high school students graduate from the ACT program since 1970.[6]

According to Jess Arnold, Manager of Rockwell's Community Interface Programs, by involving itself in the schools this way, Rockwell acts as a direct link between industry and schools and helps influence and update curricula based on changes in technology.[7] In addition, Rockwell can also help administrators understand the employment needs of the aerospace industry.

Unfortunately, the problems with education go beyond just the science and engineering fields -- and they affect more than just the high-tech industries. In today's complex and changing marketplace, even non-high-tech companies are having difficulties employing workers who do not possess basic reading, writing and problem-solving skills.

In an attempt to alleviate the skills gap, vocational education is being revitalized in order to provide one to two years of specific technical training for students not heading to college. Problems with vocational education, however, are extensive. Businesses complain that vocational graduates do not possess basic academic knowledge and skills – let alone the intangible interpersonal and communication skills required in today's work environment -- and that students are being trained in outmoded technologies.

Pending legislation on the reauthorization of the 1984 Carl D. Perkins Vocational Education Act may address some of the downfalls of the public vocational education system. In an attempt to meet the demand for integrating sufficient academic subjects with high-tech vocational training, the House version encourages high schools and community colleges to create coordinated programs of study. Referred to as "tech prep" or "2+2," these curricula would emphasize basic academics in the first two years of high school and then link the last two years of vocational training in high school with the first years of college.

In another effort to keep vocational training in line with the needs of industry, the Department of Education's version of the Perkins legislation, introduced in the Senate, would limit funds to institutions that are training students for jobs currently in demand.

At present, federal efforts to redirect vocational education are inherently limited by the inability of government to assess and determine specific local needs for vocational education. While Education Secretary Cavazos advocates coordinating vocational education and the Job Training Partnership Program (JTP) -- which works on a local level -- the Perkins program is handcuffed by federal oversight. Consequently, specific curricula and programs must be formulated at the state and community level.

In the absence of a comprehensive federal solution, many organizations have taken it upon themselves to solve the problem. For example, Hewlett-Packard and Lockheed Missiles & Space Co. are cooperating with the Sequoia Union High School District to start the Peninsula Academies. These are three-year vocational programs in computers and electronics taught in high schools in Atherton and Redwood City, Calif. In addition, 40 local companies provide equipment, mentors, on-site labs and summer jobs for students.[8]

Another local initiative was started in 1986 in Texas. An advisory board composed of members from 13 companies was created to help the Leander school district and Austin Community College develop a tech prep curriculum designed to meet the needs of the local electronics industry. These are the types of cooperative arrangements which must exist in order to meet the demands of industry.

The past neglect of vocational education suggests, however, that recovery will require extensive effort and time. For its part, the fed-

eral government now sees a role for vocational education in maintaining U.S. competitiveness. The proposed increase in funding contrasts sharply with Reagan administration efforts to eliminate funding for most vocational programs. Secretary Cavazos summarized the this new attitude at the June 22, 1989 hearings of the Senate Subcommittee on Education, Arts and Humanities, when he declared that vocational education is "crucial to the success of our nation."

Tackling the Teaching Crisis Together

In the past, the education sector has been reluctant to change and unwilling to heed criticism. But as thousands of illiterate students graduate and millions more drop out, the profession of teaching has developed a serious image problem which threatens recruitment of the next generation of educators. Furthermore, teachers and their unions have been negligent in associating the educational decline with the parallel drop in national support for teachers.

School systems across the country are currently losing many of their skilled teachers due to retirement or transfers into private industry. They are simultaneously failing to attract qualified people to become tomorrow's teachers. In a study reported in *Phi Delta Kappan* in January 1987, researchers who polled 589 high school students found only eight percent to be "very interested" in teaching as a career.[9]

Judy Lanier, dean of education at Michigan State University, describes an additional aspect of the problem. The teaching shortage, she maintains, is not so much a problem in terms of the numbers of teachers, but in terms of the quality of teachers entering the field. The best and brightest aren't being hired – the cheapest are.[10]

Nevertheless, the numbers still don't look good. In March 1989, the *Wall Street Journal* reported that "only 1500 education majors qualified to teach math and science are graduating annually – one such teacher for every 10 school districts in the country to fight over."[11] This shortage has caused districts to use unqualified teachers who water down material and adjust curriculum to their own minimal level of comprehension.

The burden of solving the problem must ultimately rest with individual states and communities. The New York Board of Education has taken the lead by creating the Math & Science Relicensing Program in order to reduce the costs of initiating new teachers in these important fields. Since its inception, the program has awarded over 400 licenses in math and science to veteran teachers from other fields.

The funding for the relicensing comes from the city council and city controller. Recertification classes are held at local colleges and universities during evening hours and over the summer so they do not interfere with regular teaching schedules. The program is free of charge and open to any teacher interested in expanding skills and upgrading credentials.[12]

Relicensing current teachers is a step in the right direction. In the future, however, the education establishment will need to look more toward non-traditional sectors of society to increase the pool of qualified teachers. School systems will no longer be able to rely on white, suburban females to be the dominant supply of teachers.[13]

Teachers will have to be drawn from minorities, especially when it comes to handling the increase in multicultural and multilingual student bodies. In addition, administrators are going to have to restructure teacher certification guidelines so professionals from other fields can pursue teaching careers.

At the National Education Forum, sponsored by Americans for Generational Equity and the Carnegie Foundation for the Advancement of Teaching, in Washington D.C. in June 1989, educators criticized the inflexibility of the recruiting process for teachers. Instead of welcoming scientists and engineers into the teaching fold, the system turns them away.

Other groups of educated workers should also be welcomed as teachers and offered non-financial compensation and benefits that might not be available in private industry. School systems should seek interested indi-

viduals for part-time work, offer maternity leave or make use of short-term teaching assignments. But because administrators and unions have been reluctant to develop programs designed to integrate qualified professionals into their school systems, they are seldom employed.[14] Curiously, the system cries out for qualified teachers while simultaneously shutting its doors to motivated applicants.

If the unions cannot see their way toward allowing professionals from other disciplines to teach in the classroom, they should, at a minimum, tap into the skills and knowledge of these experienced individuals to help upgrade and reeducate teachers. For example, retired members from the military services and business community, especially in the technical fields, could serve to bridge the gap between what is happening in industry and what is being taught in the schools.

With limited room for additional staff in school budgets, more school administrators are establishing organized volunteer programs as a low-cost, viable route to improving and maintaining school performance. Currently over 4.3 million citizens in the United States volunteer in the public schools on a full-time or part-time basis.[15]

School volunteers allow teachers more time to work with students by freeing them from routine tasks. With the increasing numbers of retired professionals and members of the business community who are expressing interest in working with the schools, the resource pool for volunteer programs is enormous.

The National Association of Partnerships in Education has established a formalized recruiting and training program to provide the nation's schools with trained and competent volunteers. The program works very closely with teachers in order to make the integration of volunteers into the schools a smooth process. With the support of grants from the Ford Foundation, programs exist in 20 large cities across the nation. For example, intensive volunteer programs have been started in Boston, Chicago, Los Angeles and San Francisco.[16]

Corporate involvement in efforts to improve the skills of teachers has also been increasing, especially at the local level. Companies like Westinghouse, ALCOA and Sun are adopting schools and helping to improve the teaching of science and math. They provide instruction by company personnel as well as access to laboratories, libraries and office space.

In Philadelphia, more than 30 companies have coordinated their efforts to improve the science education programs in the Philadelphia school districts. The Philadelphia Renaissance in Science and Math (PRISM) project provides grants and stipends for teachers who want to improve their skills in science. It has created an institute-program and a nine-month fellowship which allows teachers the opportunity to earn graduate credit over the summer.[17]

Florida has also been effective in harnessing corporate support in its teacher reeducation and retooling efforts. In order to combat the anticipated teacher shortage in the critical areas of math and science, business and the education system are working together to retrain teachers in oversupplied disciplines. Local industries underwrite the retraining costs and supply personnel and facilities.[18]

Teachers, however, contend that they cannot meet the needs of business and community without greater creative control over teaching methods and curriculum. Last year, a Carnegie Foundation survey found that more than 20 percent of today's teachers do not participate in choosing textbooks or instructional materials for their classes.[19] They feel like frustrated pawns instead of participants in the process.

In Rochester, New York, in an effort to attract and retain good teachers, city officials and educators are experimenting with the concept of allowing teachers greater control over classroom teaching and raising teacher salaries to equal those in other professions. In exchange for greater classroom autonomy and higher wages, teachers have agreed to work longer hours and be held accountable for student progress. High quality teachers with proven performance can make as much as $70,000 a year.[20]

And seniority is no longer the basis for pay raises. Student improvement and performance is. Rochester plans to use high quality teachers to serve as mentors for novice teachers and to advise other teachers on how to improve their performance.

Accountability is a new concept in the teaching profession and is as yet untested. Not all teachers welcome additional responsibility or the idea of firing teachers who don't measure up. Teachers have also expressed concern over the competitive working relationship these new concepts might create.

The other dimension of the teaching crisis involves the schools themselves. Magnet schools, or choice schools as they are popularly known, have become the anticipated salvation for the crumbling public school system of the United States. David T. Kearns notes in *The Brain Race*, "Our public schools are a priceless national resource, and we must reinfuse them with their sense of democratic purpose. But to do so, they must change radically, and choice among public schools is the change we need."[21]

Choice schools, which began as a more palatable form of desegregation, have evolved into a tool for installing free-market competition into the "monopolistic" public school systems. These schools offer diverse curricula and teaching methods. Parents review their options and determine where their children should attend. According to the theory, schools which do not meet the expectations of parents and students will lose enrollment, become economically non-viable and shut down. Survival of individual schools, therefore, depends upon the ability to meet consumer demands for excellence in education. Choice schools also offer to students with different skills, needs and interests curricula choices geared specifically toward them.

Choice schools currently enjoy tremendous support, including strong approval from President Bush. As stated in *Building a Better America*, "The Federal Government now finances magnet schools to further desegregation. This approach should be applied to achieve other worthy goals as well. Some school districts have used magnet schools to focus resources and attract students to mathematics and science . . . Magnet schools increase choices for parents and students and generate healthy competition among schools. These features improve the quality of education."[22]

For his part, President Bush said, "Magnet schools are a way of promoting excellence and upgrading the quality of an entire school system." He also proposed an increase of $100 million in 1990 for magnet schools.

Are choice schools part of the answer for qualifying a competitive workforce for tomorrow's industry? Proponents contend that they would not only raise the overall level of education, but they would also help improve and emphasize specific curricula, including math and science.

Critics argue, however, that choice schools run on consumer demand and that parents and students demand arts, humanities and talented and gifted curricula more often than they demand studies in math, science and technical areas.

Consequently, a similar problem to the one that exists in traditional schools is also occurring in choice schools: there is inadequate input from industry on curriculum development. Students, therefore, may still need to be retrained by industry in order to meet employment requirements.

On the positive side, choice schools provide the mechanisms for successful vertical integration. For instance, a choice school of math and science at the elementary level can track students into similar schools at the subsequent junior high and high school levels. Therefore, an interest in math and science fostered early can be encouraged and maintained until graduation from high school and possibly lead to post-secondary study. Prince George's County in Maryland offers a science, mathematics and technology choice curriculum that emphasizes "independent analysis, critical thinking, problem-solving and decision-making" at six elementary schools and five middle schools. The middle school programs are specifically designed to prepare students for work at two Science and

Technology Centers and for study at the math and science high school.[23]

Choice schools can also meet the needs of minorities, who represent a growing segment of tomorrow's workforce. In East Harlem, New York, a choice school has been given credit for raising the high school graduation rate to 90 percent, a remarkable statistic for an inner city school. Nathan, a senior fellow at the University of Minnesota's Hubert H. Humphrey Institute of Public Affairs, states, "If a choice plan is designed correctly, there is very clear evidence that it will have a dramatic, positive impact on inner-city kids."[24]

Still others contend that one of the pitfalls of choice schools might be the tendency to discriminate between students with past educational success and those with inadequate educational histories. That might mean that wealthier families will reap greater rewards from the system.

According to an article in the *New York Times*, "One danger, just about everyone seems to agree, is that the plans can polarize the educational system of strong and weak schools. Donald Moore, executive director of a Chicago research organization, Designs for Change, studied magnet schools in Boston, Chicago, New York and Philadelphia and concluded that they fostered 'a new form of segregation by social class and by previous success in school. Magnet schools attract the best teachers and often get additional funds, and middle-class families of all races figure out which schools are the best and end up getting their kids in those schools. This leaves the vast majority of families out in the cold.'"[25]

Cambridge, Mass., considered the shining example of the choice system, has avoided this problem by making choice schools compulsory. With the entire public system composed of choice schools, the tendency to diverge into "good" and "bad" schools is not as strong.

Interestingly, the strongest opposition to choice schools has come from school administrations and teachers. The *New York Times* reports that educators "argue that giving parents the chance to move their children from school to school will make educational planning difficult. They say it could threaten the viability of schools and even entire districts in rural areas because of a loss in enrollment."[26]

If choice is to have any chance to succeed, teachers and administrators must cooperate fully and give their support to this educational alternative.

On the Road to Partnership

Historically, educators and administrators have looked toward industry for financial support and contributions only when state and federal funds were being cut or running out. Corporate support was often limited to the role of retraining within its own walls, and industry was never actively encouraged to deal with concrete educational issues like curriculum reform, career preparation or teacher pay.

In the past, this approach left many school-industry partnerships too fragmented and short-lived to achieve significant results. It is now clear that industry is going to have to play a considerably larger role in educating potential workers before and after they leave the school systems.

The scale on which past industry-education partnerships were established represents another limitation. Traditionally, partnerships were formed with large, Fortune-500 companies that offered donations to schools from their corporate contribution budgets, but did not contribute personnel or time.

Even when corporate volunteer programs existed, some companies conveyed mixed signals to employees: which had priority, school involvement or responsibility to the company? Fred Cross, an advisory system analyst with IBM Systems Integration, believes that industry has not given employees confidence to become involved in partnerships on a long-term basis. He suggests that employees would have a greater sense of commitment if their volunteer time was better appreciated and integrated into their performance reviews. Industry partnerships also suffered in the past because they lacked high-level endorsement by corporate leaders.[27]

But that may all be changing -- positive signs abound. Corporate support and partici-

pation has become a company-wide activity, reaching the highest rung of the corporate ladder. Senior executives have been giving middle and lower-level managers the signal that education reform is a legitimate company activity and should be fully supported and encouraged. CEOs are also going into the plants and offices – circulating memos and making speeches – and asking managers to increase the awareness and participation of their workers in educational programs.

In June, the *Washington Post* reported that involvement is no longer "a civic responsibility to be handled by lower-level assistant vice presidents and members of the community affairs staff." Instead, "chief executives across the nation are now stepping into the educational fray."[28]

There are many examples of this shift. Among the nation's largest companies, the most visible and outspoken corporate executive on this topic is David Kearns, chairman of Xerox. In his book, *Winning the Brain Race*, Kearns advocates that companies take a more active role in education, and that educational institutions take a corporate approach toward reform.[29]

To maintain this high level of support from industry, teachers and administrators are going to have to show the private sector progress and results, reinforcing the idea that industry's involvement is essential to the success of school reform. Partnerships cost industry time, money and resources. Although the willingness to participate exists now, businesses will want to see signs of improvement in the schools.[30]

Many earlier attempts at forming educational partnerships failed to take off or reap any meaningful long-term results because they were not partnerships in the true sense of the word. More often than not, they were simply programs developed by school administrators and funded by business. Such programs usually failed to survive corporate contribution budget reviews for more than a few years. Additionally, they did not foster any sense of cooperation or commitment between the school and the employees of the sponsoring company.

Leaders from the business community have indicated that the quickest way to lose private sector interest is to devise an education plan purely from the school's point of view and then ask a company to pay for it. According to this opinion, partnerships would be more successful if they were approached with this idea in mind: what can the school system do for the community and surrounding industries? – not the reverse.[31]

To succeed in partnership, schools and industries must have a clearly defined plan of action designed to achieve mutually beneficial results. To be effective, any plan must involve both sides at the outset, and that is the direction collaborations are now taking.

Businesses and schools are now benefiting from an exchange of services and information: industry is giving students exposure to high technology, and schools are providing reading, writing and math instruction to unskilled employees or offering career retraining.

Since teachers are in the business of educating and training, and industry has the resources to finance training centers and programs, the case for more exchanges is compelling. Schools might even generate additional revenue by providing such services to industry.[32]

For its part, industry has only recently become politically active in educational public policy issues. At a time when fewer members of the voting public have children in the schools, public support for education reform is dwindling. Increased funding is no longer a popular issue. Industry, therefore, should pick up this role and direct the course of education reform through the legislative process. In its recommendations to the business community, the Business Roundtable stated that since there is no national minimum curriculum standard, businesses should get involved with issues such as curriculum reform and federal funding for programs that better prepare students for employment.

CEOs have been going to bat for public education at both the state and federal level. For example, the former chairman of Procter and Gamble, Owen Butler, has been active in getting Ohio to raise taxes in support of educa-

tion. Eastman Kodak President Kay Williams has also used private sector influence to get the city to increase teacher salaries in the Rochester schools.[33]

More and more, industry is comprehending the benefits it can reap by getting involved – and the costs it will have to carry by sitting on the sidelines. No matter how extensive "in-house" corporate training and education programs are, industry has to rely on the public schools to graduate a sufficient number of educated workers. With a dropout rate in some urban schools of nearly 60 percent, industry has by necessity increased its support of public education efforts to keep students in the school system before they are permanently lost.[34]

Considering that dropouts eventually become burdens on society and the overtaxed social welfare system -- in 1986 alone dropouts cost the economy an estimated $147 billion in lost earnings and tax revenue -- industry's efforts are equally important to each and every taxpayer.[35]

In one case, Digital Equipment Corp. in Massachusetts, realizing that its continued success was in jeopardy, became actively involved in reducing the dropout rates in its area public schools. The company, together with the local school system, created the Cooperation Federation for Educational Experiences which combines both educational and occupational training. The partnership focuses on the "at risk" students, those who have either dropped out or those who are on the verge of dropping out. It provides realistic solutions and preparation for students who are frustrated or perceive few rewards for the future by staying in school.

Students involved in the program are given exposure to and training for a variety of entry-level positions within the high-tech industry. The program's purpose is to foster a sense of hope and show students that there are opportunities available to them if they stay in school. The renewed success of the school system has made the collaboration a model for others interested in reducing the numbers of dropouts and providing career training for at risk students.[36]

The experiences of the seventies and early eighties have shown that the problems associated with education cannot, and will not, be solved with additional funding and increased corporate financial support alone. A more collaborative effort by all concerned groups is required, one which places greater emphasis on human involvement.

In his article for the *Chronicle for Philanthropy*, Paul Ostergard, president of General Electric Foundation, argued that "companies must get over the notion that they can solve the problems of the schools by getting out their checkbooks." He went on to explain that this approach has kept companies at "arm's length" from the children they claim to be trying to reach. Ostergard called instead for the redesign of business/education partnerships, placing greater value on the role of individuals and public interest in the future of students.[37]

Susan Phillips, director of the Milwaukee Education Trust, agrees that money is not the issue and that human resources, not capital, will bring about long-term solutions. "The problem with many business and education partnerships," she says, "is that, when a company makes a contribution to a school, everybody gets that 'warm and fuzzy' feeling that things are going to change because there is industry involvement."[38] But a financial donation alone means that the company is usually not in it for the long haul.

In the same way that industry has remained isolated from educational institutions, the education establishment has not been attuned to changes in industry. For the sake of U.S. growth and continued competitiveness, these two entities are finally coming together to provide realistic avenues for approaching the technical manpower shortage facing this country.

Businesses have taken the first successful steps toward improving U.S. education and qualifying the workforce. They know where the educational system needs to go, and partnerships provide a means for communicating this knowledge and information to the school systems. The success of any collaboration, however, will depend upon how well indus-

try can translate its needs, and the degree of skills necessary for entry-level jobs to the school systems and then work with the schools to incorporate that information into curriculum. Overall, industry is heading in the right direction.

Solutions: A Few Trees Take Root

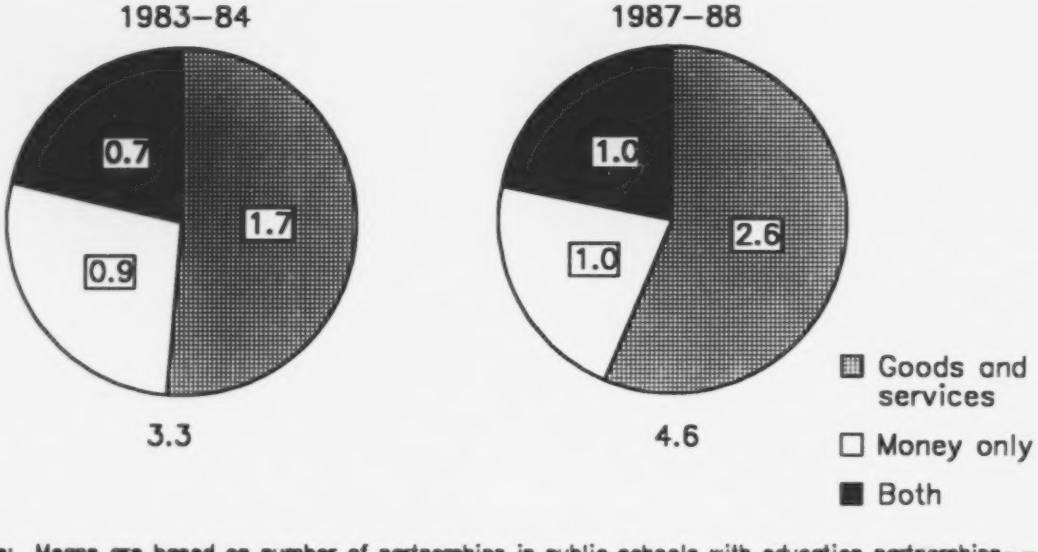
Businesses and educators who understand their interdependence and work with each other are clearly achieving results. One community which has seen the light and is reaping the rewards of industry and education cooperation is Prince George's County in Maryland. Three years ago when its superintendent expressed his concern that career education programs were not preparing students for employment, the school district formed an Advisory Council for Business and Industry, made up of over a hundred members from both the private sector and educational system.

A task force was created to assess the deficiencies of recent graduates and determine how the system could improve its curriculum to meet the needs of industry. It developed 30 recommendations for the school system which it felt would improve the long-term employability and success of the Prince George's County students. Based on these recommendations the school system went on to develop the Guaranteed Employability Program, which was launched in 1988.

The program is based on an agreement between the business community and the school system, which states that businesses will continue to hire students from the community and continue to work with the school system, if the school system guarantees the students' skills and employability.

But how can a school system guarantee the skills of its students? Prince George's County did it by promising to retrain and reeducate the new employees in areas where the employer identified inadequate levels of performance. Upon graduation students are

Working Around the System: Partnerships Grow



Note: Means are based on number of partnerships in public schools with education partnerships--40 percent of all public schools.

Figure 17.

Source: US Department of Education

given a Guaranteed Employability Certificate stating that they are competent in reading, writing and math. This past June, 2,500 students were awarded certificates.

Jacqueline Lendsey, executive vice president of the Advisory Council for Business and Industry, claims that these students will have a true advantage over others in the workforce because their future employers have taken an active role in preparing them for work. She attributes the business community's desire to become involved with the school system as one way to "ensure the economic vitality of the community" by graduating educated and prepared students.[39]

The Louisville Education & Employment Partnership has similar objectives: to increase educational and employment opportunities for youth through a written agreement between local employers, schools, parents and students. At the outset of the partnership, a contract between student, parent and a partnership representative is signed by each party stating that they are aware of their responsibility in the partnership.

Companies also sign "letters of intent" which state that they will give priority hiring to partnership participants for both part-time and summer jobs and give hiring priority to qualified graduates of the partnership for entry-level positions in the company. The company must list vacancies and required skills with the partnership to ensure that students are aware of openings. In addition, the company must direct applicants without high school credentials toward educational opportunities and encourage them to obtain high school equivalent credentials.

In return, the student commits to maintaining a 95 percent school attendance rate, improving classroom performance, and meeting the expectations of the employer while at school and at work. The student sets standards in grades and work, and then attempts to meet or exceed them. The student must also participate in career preparation activities, such as completing employment applications and mock interviews. Since all parties sign contracts agreeing to work toward their goals, there is a greater sense of commitment. Clearly, in the corporate world a "letter of intent" is taken more seriously than a verbal promise.[40]

The economic logic behind industry involvement in these programs is sound. That may explain why industry is more involved with education than ever before. In February of this year, the U.S. Department of Education reported that 40 percent of the nation's elementary and secondary schools were involved in some kind of educational partnership during the 1987-88 school year. Over half of these partnerships were with industry.[41]

Some educators, however, have expressed concern over the scope of industry involvement, especially when it comes to funding. They claim that by controlling the purse strings, companies may gain too much influence over the direction of education. For example, some critics believe that certain industries may only be interested in securing employees for their particular industry and not in providing broad-based training that might translate into other fields.[42]

For instance, Bella Rosenberg of the American Federation of Teachers indicated that the Marriott Corporation has been criticized for producing narrowly skilled employees in order to alleviate their immediate labor shortages.[43]

Corporate involvement has also been attacked because in some cases it widens the gap between rich and poor schools. The task of preparing students for engineering positions with the nation's high-tech companies is not necessarily the same as teaching children in the inner city schools how to read. This has prompted considerable debate over where corporate funds can be best used and where educational priorities lie.

There is also the issue of whether all school systems have the same access to potential corporate donors. If influence is a prerequisite to soliciting support, partnerships might fall victim to the same imbalances and inequalities that past education reform has. For one thing, school districts in affluent areas tend to have greater parent involvement and community support. Additionally, as Lynford Kautz, executive director for Fairfax County Public

Schools Education Fund, admits, the company-supported Thomas Jefferson High School would have had a much harder time getting corporate funding for its science and engineering programs had it been located in a less affluent area which did not enjoy the presence of an ample number of large high-tech companies.[44]

But even though industry involvement and financial support has raised legitimate concern over further delineating schools into the "haves" and the "have-nots," industry involvement must be supported. While precautions are necessary, industry's efforts are producing positive results. Additional efforts must not be discouraged by predicting and emphasizing the negative.

From all recent evidence it seems quite clear that industry and the educational establishment understand the problem, are very much aware of the implications of the past decline of the U.S. education system, and in many communities have started working together to solve the problem.

Tomorrow's Workers: Train Them Now or Lose the Race

In March, the *Wall Street Journal* reported that half as many black men are in jail as in college. Therefore, rethinking minority needs and removing barriers to higher education and professional careers is more important than it has ever been.[45]

Too few programs, at all levels of the educational system, refuse to focus on the long-term needs of minority students. These students typically come from disadvantaged backgrounds and are less likely to have adequate schooling or training. Not only are they unprepared for the jobs of today, but they are also woefully incapable of handling the high-tech jobs of tomorrow. Unless this situation is remedied, the United States will lose out altogether in the global technological competition.

Fred Cross, an advisory systems analyst for IBM's Gulf Coast Alliance for Minority Engineering, believes that the only way to increase the number of minorities in high-tech fields is to get them through the educational "pipeline," from grade school to high school and into college. The problem, as he sees it: minority students attend schools ranked in the lower 25th percentile. These schools do not attract enough high-quality teachers to offer a large selection of math and science courses. As a result, potential technicians, scientists and engineers are rerouted into introductory or remedial courses which do not satisfy college prerequisites.

This "low leveling," according to Cross, is what holds minority students back and prevents them from being able to qualify for college programs in the engineering fields. Furthermore, minority students and their parents are often intimidated, misinformed by the system or do not fully understand their rights to choose the direction of their education.

The Houston-based Gulf Coast Alliance for Minority Engineers makes use of IBM personnel to help inform minority students and parents of their rights as well as the opportunities available to them in the engineering fields. Before entering high school, students are assisted in preparing their course plans for the next four years, including four-year sequences of math and science courses. As a result of student interest, school systems have restructured their course offerings to help provide better training in these fields.[46]

Unfortunately, even after completing four-year high school programs many minority students face the problem of getting into affordable colleges and universities. Unless their grades and SAT scores are high enough to qualify for scholarships or grants, entering college is not within their economic means. Furthermore, many colleges and universities have been reluctant to accept students with low to average grades who want to enter engineering programs. When minority students do make it into college, a whole new set of problems emerges. The transition to rigorous, highly competitive engineering schools is a difficult one for most minorities.

The National Action Council for Minorities in Engineering, Inc. (NACME) recognizes the need to provide assistance to minority students and strives to increase the numbers of

minorities graduating from engineering schools. It is the nation's largest private supplier of grants and scholarships to minorities in engineering. NACME also offers counseling for pre-engineering students and publishes guides to engineering colleges, listing curricula offered, support activities and financial aid available.[47]

Nevertheless, integrating minority students into the technical manpower pool will not happen automatically. It must become a priority of colleges and universities. But few post-secondary institutions today have mechanisms in place to help minorities adjust to a world in which they are underrepresented and sometimes feel out of place.

Many programs also tend to overlook the lack of parent involvement in predominately minority school districts. Barbara Russell, director of the Memphis Adopt-A-School Program, says that one of the ways businesses can help disadvantaged students is to provide to them what they are not getting at home. For instance, many companies have offered their facilities as quiet, well-lit study retreats from overcrowded homes. Businesses can also donate school supplies which many families cannot afford.[48]

Lack of parent involvement is a problem many programs for minorities attempt to overcome. Cornell University, with funding from Chase Manhattan Bank, has embarked on a model Parent Involvement Program in New York City School District 10 in the northwest Bronx. After full implementation and study, Cornell intends to replicate the program in other districts in the city. Most of the children served by the program come from disadvantaged, one-parent homes. The program's aim is to "increase parents' involvement in their children's learning, increase communication between parents and schools, and further children's development emotionally, socially and academically."[49]

Mentoring programs provide another way to counteract the effects of inadequate parent involvement in a student's education. Mentoring programs have had considerable success at motivating students to stay in school who might otherwise consider dropping out. They also provide support and guidance for the transition from school to work or higher education. Mentors can assist students in specific areas of educational difficulty or provide emotional support for issues relating to family and peers.

New York State has had one of the most successful and extensive mentoring programs to date. In 1988, the New York State Mentoring Committee was formed to solicit business and community support for mentoring programs. It began on a local level and is currently forming a clearing-house and networking center to extend mentoring programs in the 15 districts of the state. The programs rely on mentors from all walks of life and all professional backgrounds. They require a commitment of at least a year and the desire to provide the special attention many disadvantaged students need.

Matilda Cuomo, the Committee's chairperson, explains that the program goal is to "start mentoring programs for one-to-one counseling, building a new kind of extended family that will give kids the skills and hope for the rest of their lives."[50]

Tutoring, like mentoring, is an additional means of offering disadvantaged students the opportunity to work on a more personnel level with someone who has an interest in their education and success. One exemplary tutoring program is The Washington Education Project (WEP) based in Washington D.C. The program takes advantage of one resource in abundant supply – undergraduate college students -- to compensate for less available teachers. Everyone involved seems to benefit: the college students earn college credit and invaluable tutoring experience; the classroom students receive extra help and attention. In addition, the teacher's workload is decreased so more time can be spent with students in need of special help.

The WEP raises funds so it can provide $25,000 grants to colleges and universities which agree to participate in the programs. Contributions to WEP come from corporate donors like Xerox, Manufacturer Hanover and Hughes Aircraft. Smaller companies are also encouraged to contribute, as WEP attempts to

match smaller grants of $5,000 with $20,000 grants from the larger companies. The donations are used to cover the start-up and administrative costs of the programs for a two-year period.

The focus of this program -- different from other student-teacher and volunteer programs -- is squarely on the student. Rather than attempting to meet teacher demands, volunteers meet student needs. The undergraduates, who work for credit with students on a one-to-two ratio, do nothing except tutoring. They are not expected or allowed to grade papers or monitor non-teaching activities. They are there to teach and help students learn. It is this type of individual attention that children and adults threatened by illiteracy and unemployment need.

The Project's director, Norman Manasa, says that the most important goal of the project is to allow the disadvantaged to create wealth through education and to "bring the light of learning to those places that have known only illiteracy, poverty and despair."[51]

The project is currently working in 12 colleges throughout the United States and has approximately 150 tutors enrolled for the fall 1989 semester. Since cities have an abundant supply of undergraduate students, the potential for tutoring in public schools is enormous. In Boston alone, if only one percent of the over 100,000 undergraduate students in the area were involved in a similar project, their participation would generate over 60,000 hours of tutoring per semester for the Boston public school system. Five percent of eligible students would produce 300,000 hours each semester. On a national scale, even a small percentage of the more than 10 million undergraduates could make a tremendous difference.[52]

Women constitute another pool of untapped workers. Women, however, are not minorities in the true sense of the word. In fact, they will progressively make up the majority of the workforce. To ignore them as an element of industrial competitiveness is to ignore the greatest untapped potential in the technical manpower area.

According to Sheila Widnall, professor of aeronautics at the Massachusetts Institute of Technology, "If the number of (Ph.D.) women could be increased by a factor of 2.5, the predicted shortfall in scientific and technical expertise could be avoided altogether."[53]

Since the majority of women are already succeeding in high school and getting into college, the problems are different than those encountered when trying to channel minority students into technical fields. The main obstacle, involves changing women's interests. At the 1989 National Aerospace Symposium for Educators, Susan Agruso of the New York State Education Department suggested that if high school programs required more math and science during the four years, women would not be able to avoid these studies and, consequently, would not be shut out of college programs. As with all students, preparing women for technical careers must begin early in the educational process.[54]

At a time when U.S. competitiveness is being threatened by a shortage of skilled scientists and engineers, universities and industries are not doing enough to increase the numbers of women in these fields. The Chronicle of Higher Education reports that, after increasing for several years, the number of women graduating with bachelor's degrees in science and engineering has slowed and seems to have reached a plateau.[55]

To date, there have been very few formal programs geared toward increasing the numbers of women pursuing degrees and careers in science and engineering. For its part, the government should increase the portion of the federal R&D budget which goes to women in engineering now and give more recognition to women researchers and their projects.

Likewise, colleges and universities have not committed themselves to attracting women into the engineering fields. Efforts should begin at the high school level before students begin to select their colleges and fields of study. University recruiters could become active on high school campuses, speaking to women about the opportunities in science and engineering.

In addition, the business world must

Women: Underpaid but in Demand

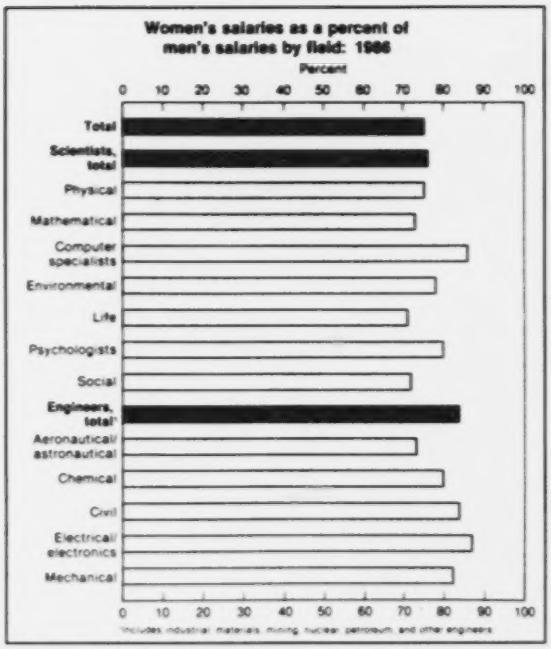


Figure 18.

Source: National Science Foundation

change long-standing pay and benefit policies in order to create an environment that will attract women to high-tech industries. For instance, women scientists and engineers tend to be paid less, and promoted less often, than their male counterparts.[56]

The Defense Establishment: Doing its Part

Past initiatives by the defense establishment to solve the technical manpower shortages have included working with vocational schools, heavy investment in recruitment and scholarship programs and university cooperative ventures.

Ties between the defense establishment and vocational educational institutions have existed for some time. According to one author, "Preparing workers for national defense has long been a priority in vocational education. During World War II more than 7.5 million skilled defense workers were trained in over 1,500 vocational education centers throughout the United States in just five years."[57]

DoD and the Department of Education at one time cooperated extensively. According to John K. Wu, "In the interests of national security, the Office of Vocational and Adult Education (OVAE) in the Department of Education (DOE) has cooperated in many ways with the Department of Defense (DOD) for a number of years."[58]

Cooperative ventures began with the October 1, 1981 National Task Force on Defense Preparedness and Vocation Adult Education and the subsequent seminars on Vocational Education and Defense Preparedness. In addition, a number of studies were conducted, including Responding to Defense Industrial Base Training Needs (1984) by the Office of Vocational and Adult Education and OVAE's Increasing Collaboration between Vocational Education and the Defense Establishment.

The efforts of the departments focused on promoting the training of skilled technicians for the military sector and the defense industries, identifying shortages in the workforce which could adversely affect national security, providing materials for teaching technical fields, and recruiting retired military personnel as teachers in vocational institutions.

But of late, these cooperative programs seem to have disappeared or have been swallowed up during the transition from one administration to the next. According to both departments, little is known about past cooperation, and there are no signs of any new initiatives on the horizon.

Retraining programs have also been created between specific military bases and local vocational institutions, predominantly community colleges and vocational institutions. Notably, at Tinker Air Force Base in Oklahoma a Vo-Tech Center was built as the result of a cooperative venture between Tinker and the Oklahoma State Department of Vocational and Technical Education. These and similar programs, however, focus on retraining, not on recruiting or on improving the educational quality and quantity of new entrants.

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Of course, DoD cannot solve the entire vocational education problem alone. While it is necessary to support local institutions in order to strengthen recruitment ties, it is even more beneficial to support improvements in the entire high school and vocational education systems. One goal of the Human Resources Committee of the Defense Manufacturing Board "to stimulate broad national attention to the need for strengthened technical education," is a step in that direction.[59]

As summarized in the Vocation-Education Defense Establishment Collaboration: State-of-the-Practice Report (1985): "Vocation education-defense establishment collaboration should be viewed as part of a much larger problem of industry-education cooperation, or more appropriately perhaps, employer-education cooperation. Defense preparations are not independent of other urgent concerns (such as stimulating economic development and enhancing industrial productivity) that impact on skilled labor."[60]

On the other hand, education programs instituted by DoD and the armed services are numerous. The 1988 DoD White Paper described them by divisions from pre-college through post-doctoral programs. At the pre-college level, the majority of initiatives are relatively small in scope. For example, the Department of Defense Science and Engineering Apprenticeship Program, which is one of the larger initiatives, involves only around 1,000 students each summer. Other programs are limited to between approximately eight and 100 participants.

The aim of most of these programs is to build interest in the science and technology fields and to encourage talented students -- including a high proportion of minorities and less-advantaged children -- to pursue technical studies. No information, however, was available on whether these programs provide the services with a direct payoff in terms of recruitment.

Any programs which encourage and expand interest in the science and engineering fields, however, probably benefit DoD and the military services in one way or another. In addition, these programs represent initiatives that could be incorporated on a nation-wide basis in schools, building enthusiasm and interest in math and science through volunteer teaching, field-trips and mentor systems.

The majority of programs, such as The Army Research Office/Office of Naval Research Uninitiated Introduction to Engineering (UNITE) Program and The Army Research Office Computer Related Engineering and Sciences Studies (CRESS) Program, direct their support toward women, minorities and disadvantaged children, the very pool from which the future technical workforce will need to be increasingly drawn.

The Defense Mapping Agency's Pre-Freshman Engineering Program (PREP) is an eight-week summer program in San Antonio which encourages talented students to pursue science and engineering careers. A follow-up study of the PREP program conducted in 1987 indicated that of the 555 respondents, 416 attended college and 275 were enrolled in engineering and science courses. Out of 73 graduates, 55 were engineering and science graduates.[61]

Post-secondary programs, for their part, are designed to directly recruit employees into DoD and the armed services since they largely involve tuition and financial assistance in exchange for employment commitments to the sponsoring institution. The broadest and most popular programs include the Cooperative Education Program (CO-OP) and the Reserve Officer Training Corps (ROTC).

The Department of the Army's Scientific and Engineering (DASE) ROTC CO-OP programs represent another approach. The goal is to encourage scientific and engineering (S&E) students to join ROTC and become military officers or to work as government employees. The program is, however, severely hampered by its limited scope. As of August 31, 1988, the Army had only 42 participants. Ten were drawn from minorities and seven were women.

The Army is also now offering $17,000 in college funding to qualified young men and women who sign up for two years of active duty for non-combat jobs. In the past,

Congress limited two-year enlistments to males who were willing to serve in combat jobs.[62]

While many of these established programs do not necessarily guarantee recruits for the defense sector, they do work at the local level and raise the overall engineering capacity of the nation.

Delbert Spurlock, former assistant secretary of the Army for manpower and reserve affairs, argues that defense efforts could be translated into civilian training efforts. He states that "the Army should ensure the maximum societal benefit from its departing soldiers by actively assisting their transition to public- and private-sector employers who can take immediate advantage of their skills -- such a policy would help the Army recruit. The benefit to the Army: A growing societal understanding and willingness to fund excellence in Army training. The benefit to the nation: more than a million men and women equipped and capable of equipping others for the 21st century."[63]

The Air Force Research in Aircraft Propulsion Technology (AFRAPT) Program, for its part, employs private firms and universities in an effort to bolster a single technical specialty of the defense and aerospace sectors. This program began in 1982 in order to attract students to research in aircraft propulsion technology. Today it is operating at five universities which offer Ph.D. degrees. AVCO Lycoming, Detroit Diesel Allison, Garrett, General Electric and Pratt and Whitney Aircraft are also active in this program.

To be accepted into the program, graduating seniors must be accepted for part-time employment by one of the companies and for graduate work by one of the universities. Each participant is a full-time, paid research trainee of one of the universities. What is notable about this program is that it combines defense, educational and industrial support to help maintain U.S. competitiveness in a specific technology.

Apart from DoD and service programs, many companies have ventured out on their own to try to solve their local workforce problems. For instance, Hughes Aircraft in Orangeburg, South Carolina, and South Carolina State College (SCSC), recently joined forces to improve the educational and economic outlook for the college, the state, and the company by donating $10,000 -- with more funds to follow -- to initiate a collaborative partnership.

SCSC will perform as a subcontractor for Hughes and participate in research and development of components and sub-assemblies for military systems. Meanwhile, Hughes will provide co-op and full-time employment for students and summer internships for faculty. The company will also provide advice on technical curriculum development, assist with staffing, and supply equipment to the college

While the two institutions have had a history of cooperation through advisory committees, the underlying goal of this more extensive collaboration is to improve the quality of graduates from the college. According to Dan Peck, Vice-President and General Manager at Hughes, "We have not been terribly pleased with the output of schools today." Therefore, rather than "sit around and whine and hold a lot of meetings, it makes more sense to go to the root of the problem and work to solve the problem."[64]

This is exactly the kind of cooperative program that is aimed at solving technical manpower shortages over the long-term. Dan Peck stated that Hughes "definitely considers this a long-term investment and involvement. Too many companies today just give money and then step out." He indicated that monetary solutions alone are short-sighted and ultimately do not improve the quality of technical graduates, implying the high costs of retraining that industry complains about are often the result of its own short-sighted solutions.

At present, this program is limited to post-secondary education. In the future, similar programs should be considered for high schools, since interest in science and engineering needs to be nurtured at earlier stages.

For his part, Dan Peck recognizes the limits of the present SCSC-Hughes collaboration. But, he adds, "I hope this is just the beginning. We really need to reach into the prep schools,

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secondary schools and elementary schools. But this is a good start."[65]

Another innovative approach by defense industry involves a type of educational brokerage firm. Located in the defense-oriented Orange County in Southern California, the Technology Exchange Center (TEC) functions as a non-profit liaison between industry and local educational institutions to meet the technical manpower requirements of industry.

Industry consults TEC and discusses workforce requirements for specific projects or anticipated emerging technologies. TEC then analyzes local curricula to determine if any schools have programs designed to meet those specific training requirements. If not, TEC works with members of the company and an educational institution to develop an appropriate curriculum.

A spokesman at TEC indicated that the brokerage firm has proven to be a cost-effective means for companies to meet workforce requirements, most notably for the smaller manufacturers or subcontractors of military systems that do not have the resources to develop their own educational programs or to collaborate extensively with individual educational institutions.

Educational institutions involved indicate that their planning processes and subsequent curriculum development have improved. Currently, the brokerage concept is not widespread, but has worked effectively for firms in Southern California to meet their workforce demands.[66]

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FINDING THE RIGHT NICHE

Government as Engine of Change

In times of crisis, it is tempting to turn to the federal government in Washington for solutions. That may be the right answer when it comes to repelling an invasion. But, in working our way out of the technical manpower predicament, Washington can be more effective as a catalyst, as a setter of standards and an engine of change.

During the 1988 campaign, candidate Bush discussed federal government's possible roles in developing high technology. His campaign fact sheet said: "There are many active players in R&D in the United States -- federal government, state governments, national laboratories, university laboratories and business. The federal government should not attempt any kind of central planning of American research activity. However, the federal government should promote greater cooperation among these different groups.[1]

IBM Vice Chairman Jack Kuehler told a Senate committee that business must adjust to the new realities of international competition, to "get sharp or retire from the scene." He suggested that the proper functions of government in restoring U.S. competitiveness include relaxing antitrust law to enable companies to establish joint production projects, and for the Commerce Department to work as "a real catalyst" to help finance common research and development programs.[2]

The federal government can foster communication and collaboration, and set standards and policies. In fact, the Council on Research and Technology (CORETECH) included that as one of its six recommendations for improving the education and training of the current and future U.S. scientific and technical workforce. Its membership comprises 161 universities, corporations, research institutes and associations. In its policy paper that outlines the actions requested to meet the needs of the growing economy, CORETECH found that coordination among key decision-makers is often deficient. Information is not being shared, and the potential for cooperation is being missed. CORETECH urges continued federal support for collaborative efforts, and also a stronger role in promoting effective cooperation.[3]

Labor: Waking up to New Realities

Organized labor should have a vested interest in ensuring that the workforce is qualified to cope with the changes and stresses of the global marketplace. For this reason, unions should be playing an active role by providing funds and people to develop technically qualified people who can enter the labor force. Yet partnerships between labor and education are harder to find than such arrangements between educational institutions and industry. For instance, we asked the machinists' union if it was participating in the intensive training programs that Boeing was operating in order to meet production demands for its aircraft, demands so severe that Boeing paid Lockheed to borrow 670 skilled workers. The union's role in the training program, however, is passive. Its attitude: "That's Boeing's problem."[4]

That attitude is puzzling, so we asked several people active in creating local alliances to

improve science and technology education for their views. They were participants in the national leadership conference for local alliances held in July 1989. The conference was sponsored by the Triangle Coalition for Science and Technology Education, the Carnegie Corporation of New York and the Colorado Alliance for Science. Their answers, along with our conversations with union leaders, suggest that the labor movement has yet to take advantage of partnership opportunities that could be fruitful for its unions and for management and the community at large.

Connie Dietz is the manager of the Business Education Success Team for the Wichita (KS) Area Chamber of Commerce. She has been frustrated when trying to work with unions in the Wichita area. In her view unions have become so protective of their workers' rights that they see technological innovation as a threat, not as a means of providing further training to workers who require to new skills as the job market changes. She explained how she persisted in trying to recruit a key union leader into a local alliance. But when he was finally reached and invited, he declined to participate.[5]

Dr. Joan Martin Bowen, president of the Industry Education Council of California, says the reason unions are not present in these partnerships "is due to concern over their own manpower situation."[6]

On the other hand, Terry Bell, manufacturing information manager for IBM, maintains that unions should play a role in organizations such as the Triangle Coalition. Their reluctance to do so, however, can be traced back to their very roots -- and he cites the reason unions were formed in the first place: abuse of workers by business. By concentrating on organizing and ridding the workplace of abuse, they never took the lead in promoting technological innovation. However, he said, "I think there's a place for them today (in partnerships like the Triangle Coalition). I can see how they could serve as a vital link with masses of people on a broad scale."[7]

Don Mikulecky, a member of the Richmond (VA) Joint Engineers Council and professor of physiology/biomedical engineering at the Medical College of Virginia, also sees a role for unions in participating in technology education programs. But, he cautions, "they have to see it as a self-interest thing." When their self-interest becomes clear, the unions might play a strong role.[8]

There are, on the other hand, some exceptions to the unions' predominantly passive approach. Cooperation between the United Auto Workers and General Motors represents a notable exception. In a clear example of mutual self-interest, they have developed a comprehensive training and retraining program to cope with technological change. According to Howard Erickson of the UAW, two significant programs demonstrate cooperation between the union and the company in dealing with the twin perils of layoffs and training/retraining.

The shock of GM's layoff of nearly 172,000 employees in 1981 provided the genesis for the program. Following that wrenching experience, the company and the union established the Dislocated Worker Program for UAW members, which provides training and counseling. It still operates today and places 65 percent of all participants in jobs outside GM.

Additionally, to ensure that training and retraining keep up with both entry needs and changing requirements, the union and General Motors operate the UAW/GM Human Resource Center for education and training/retraining. It is available to more than 370,000 UAW members at 150 GM plant locations. Together, the UAW and GM invested $900 million to operate the resource centers in 1988. The program is mutually beneficial. It means increased job security for UAW members. For its part, GM improves its global competitiveness by cutting costs, improving quality, extending decision-making to the factory floor, and increasing harmony and cooperation.[9]

Media: Reaching Beyond U.S. Borders

The U.S. media are by far the most dynamic and aggressive in the world. Yet, print and broadcast media in the United States fall short when it comes to following the routine events that make up the global marketplace.

On a cultural level, the media reflect the American penchant for ignoring what goes on beyond our borders unless we are directly affected in some way that really matters. While America has been forced out of its isolationist complacency at different times during its 200 years of existence, most notably by the two world wars and two undeclared wars of this century, most Americans are very content to thrive "on their own."

But this inclination doesn't square with our very roots: pilgrims, pioneers, Manifest Destiny, and a man on the moon. Today, the global economy is challenging us once again to rediscover the sense of adventure that helped us build a nation that stretched from the Atlantic to the Pacific oceans and achieved world leadership.

As many studies point out, Americans need to be able to live in a world economy. But to live in a world economy means to understand the world. Finally, to be competitive, Americans need to be particularly in tune with world financial developments -- and not just those that make sensational headlines.

This is where the media come in. As U.S. government, industry and the academic community broaden their horizons, the media need to rise to the occasion and begin to convey to the American people the kind of information they need to compete globally.

As the television network anchors "see the world," broadcasting from Poland, Tiananmen Square, Red Square, and Venice, to name a few, they certainly help make Americans aware of the big news events around the world. But what of the more mundane but important trends that are, perhaps not as visually gripping? While newspapers by their nature can do a more thorough job than the 30-second bites of TV, they, too, at times fail to produce comprehensive coverage of international affairs.

Take international business news. The *Wall Street Journal*, along with other U.S. business newspapers and periodicals, do a superb job of covering U.S. business and some international news. However, to really track global economic developments, American business leaders must turn to Britain's *Financial Times* or the *Economist*. This should not be so. And, in some respects, it is not the media's fault.

The U.S. media tend to respond to what American opinion-makers define as important. Until very recently, business leaders underestimated the need to pay attention to international developments. For their part, U.S. government leaders have seldom, if ever, taken a long-term strategic view of the world. Now that our national focus is by necessity shifting toward the international arena, the media will most likely follow suit.

There are signs of a change in attitude, however. For example, most of the U.S. media in 1986 and 1987 tended to ignore the emergence of the integrated European Community planned for the end of 1992. But in the last year, coverage has expanded tremendously. And it is quite good. Likewise, economic developments between East and West Europe will be at center stage as the Soviet Union loosens the reins and focuses on its own economic restructuring.

In the end, the American media's intuition will continue to lead them toward a more international bent in their coverage. At present, however, opinion leaders should help raise overall American awareness of the importance of U.S. technological competence and its relationship to the international marketplace. In turn, the media will pick up the scent and play a valuable role in helping to further educate the American public.

Endnotes

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[4]Interview, April 21, 1989.

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[7]Interview, July 6, 1989.

[8]Interview, July 6, 1989.

[9]Interview, July 21, 1989.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The conclusions of this study are simple and stark. Technical manpower shortages have created a severe crisis for the United States. If left unchecked, they endanger its way of life and world position.

Causes of the skills shortages are easy to discern. First among them: the education system has failed the nation. It has not produced enough well-educated, technically qualified graduates who can enter the workforce and become productive members of society. This is true at every tier, from entry-level technician to research scientist. And the future doesn't look any better.

Within the education system, skilled math and science teachers are in short supply. Moreover, unions and administrators create obstacles to overcoming the shortfall. Additionally, school systems have failed to take into account the needs of U.S. industry when developing curricula. Combined, these trends guarantee that the education system will not produce the technically skilled workforce the United States needs as it moves into the 21st century.

Next, the demographic trends ensure the problem will worsen. The pool from which the workforce will have to be drawn in the coming decades consists of women, who have traditionally avoided the technical fields, and minorities, who have too often fallen through the cracks within the system. Both of these groups are now under-represented in technical fields. In fact, the nation has failed to capitalize on its human assets of all kinds.

Because the education system fails, American industry must take up the slack and invest billions of dollars in training and retraining. While U.S. companies divert scarce resources toward that end, foreign competitors are putting all their energies into doing business. The result is predictable: the United States is losing its edge technologically and will not be able to win in a competitive, global marketplace.

Local solutions to these problems are beginning to proliferate, usually as partnerships or alliances between and among businesses, education and government bodies, but they still must bypass the entrenched education system.

In effect, these actions represent local expedients; yet they only treat the symptoms of the disease, not the disease itself. These partnerships have, on the other hand, achieved results and can serve as models for a range of nation-wide holding actions designed to buy the United States time while the basic education system is overhauled.

The signs of the technical manpower crisis are all around us, and potential and proven solutions have been studied to death. Now is the time to galvanize and energize all elements of society for immediate action. That is the fundamental conclusion of this study. Basic, revolutionary reform is required. Quick fixes and cosmetic dressings simply will not do. Only complete and comprehensive reform will restore the nation's competitive edge.

Recommendations

First, it is essential to understand that actions are required at all levels. No one is exempt from this war on technical incompetence. There can be no deferments. National survival is at stake. Nor should people expect to hold back and await solutions from Washington. The federal government can and must play a role in the revolution, but it is that of leader and catalyst: setting standards, stimulating and coordinating actions nationwide. Within that context, however, specific actions can be taken by the federal government.

At the federal level:

The President has already taken the lead by establishing educational reform as a top priority. To reinforce his own leadership, he should:

- Designate the Secretary of Education to coordinate the reforms, to be an "education czar." He should require expanded coordination among departments of the Executive Branch. One example of fruitful coordination involved the combined effort of the departments of Labor, Education and Commerce to identify the key elements of the crisis in their report, *Building a Quality Workforce*, July 1988. Inclusion of other departments, especially the Department of Defense, in such coordinated efforts will yield productive results when coordinating specific actions.
- Direct that the Secretary of Education lead an information collection and dissemination effort to be undertaken by all federal departments. The Secretary should be the focal point for compiling the information into useful and distributable form nation-wide.

The Cabinet departments and General Services Administration should:

- Streamline disposal regulations and procedures to facilitate turnover to schools of excess or obsolete equipment useful in technical teaching.
- Revise acquisition regulations and policies to allow government contractors to treat funds spent on training and education as allowable expenses. Include the allowability both for internal programs directly applicable to the contract and to external programs such as business/labor/school partnerships.
- Set educational standards and goals in workforce qualification for government contractors to meet, similar to existing goals for minority subcontracting.
- Expand support for education programs into all departments. The Department of Defense operates the Veterans Education Assistance Program (VEAP), for instance. It should be expanded to provide incentives for scientists and engineers, as well as infantrymen, submariners and pilots. Similar education assistance programs should be initiated and expanded government-wide.
- Federal departments should track retiring civil service and military engineers, scientists and technicians who can be made available to academia and industry to help improve education and training.

Congress should facilitate education and training partnerships at all levels by:

- Devising tax incentives, such as creating depreciation allowances for resources committed to qualifying the workforce. An improved workforce is necessarily an intangible asset not normally depreciable. However, more qualified and productive workers produce tangible results, whether in goods or services.
- Participating with the Executive Branch and the states in information collection, compilation and dissemination.
- Supporting and validating Executive Branch actions to set goals and standards for actions to qualify the workforce.

At the state level:

The states with partnership initiatives already under way should expand them while concurrently joining in education system reform. Included in those actions:

- Stimulating federal and local actions for education reform.
- Encouraging and expanding partnerships and alliances between government, industry, labor and education sectors.

• Taking action in state legislatures to remove barriers to the implementation of innovative programs and to structural educational reform.

The private sector:

Actions by the private sector can create leverage and magnify the impact of programs already under way at local and state levels. Also, the private sector should stimulate appropriate actions by government at all levels. To be effective, interaction and cooperation is required among sectors that are not always natural allies or partners.

Industry should invest in human capital, pinpointing and quantifying the investments it makes to qualify the present and future workforce:

• Opportunities should be sought to invest in education and training partnerships at all levels.

• Stimulate government to create policies and standards that reward industry's investments.

The action statements in the Business Round Table's *Blueprint for Action* are pragmatic and achievable models for all of industry. They can be summarized as taking action now, creating sustained commmitments to reform and to state and local partnerships as well as galvanizing federal policy actions.

Organized labor should:

• Seek opportunities for partnerships with industry, government and educational institutions.

• Strive for a fundamental change in attitude directed at identifying how unions can cooperate with industry in supporting various partnership initiatives and how teachers' unions can help stimulate true structural reform by removing present barriers.

Associations nationwide should:

• Foster information exchange among members, other associations and other sectors of society.

• Act as clearinghouses and resource centers for information. They should provide database services, becoming purveyors as well as collectors.

Everyone has a role in overcoming this crisis. No one, and no part of society, can be a spectator. Technical competence and U.S. competitiveness are everybody's business.

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